THE MAINTENANCE OF MOTOR CARS.

A practical Handbook dealing with the upkeep of Motor Vehicles.

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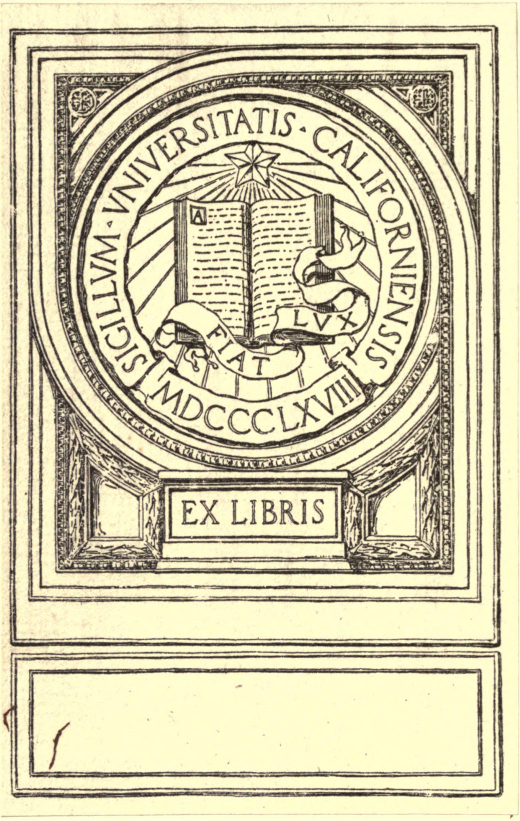
by ERIC W. WALFORD.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OF
MOTOR CARS

BY

ERIC W. WALFORD.

UNIV. OF
CALIFORNIA

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PREFACE.

As the title suggests, this book is intended to instruct the inexperienced how to look after and keep in good order their motor vehicles.

It is felt that there are a large number of owners who have had little or no experience with motor vehicles, and who consequently require a simple and elementary book explaining what is necessary. It is for this reason that the descriptions have been made as clear as possible, and that the assumption has been made that the amount of technical knowledge possessed by the reader is not necessarily large.

The book is not intended so much for the use of skilled mechanics and chauffeurs, though it is hoped that some of the information contained in it may be of use to them.

To the beginner it may be necessary to state that the upkeep of a motor is not such a difficult matter as it might seem, and he need not be frightened by the number of repairs, etc., described. As motor cars are becoming so standardised, and vary so little from year to year, there is very little now that is experimental and liable to go wrong, which could hardly be said to be the case in the early experimental days. Nearly every beginner who buys a motor vehicle does so with diffidence, thinking he is buying a great deal of trouble. In a short time he is astonished to find how very much easier it is to look after and take charge of a motor car than he originally imagined.

On the road a modern car requires practically no attention, and if one or two parts are occasionally examined in the garage, non-stop runs will be the rule, and not the exception.

The test of a motorist is, in my opinion, his ability to diagnose a trouble when it crops up, and, if necessary, to remedy it. In this connection the chapter on "Diagnosis" should prove useful.

ERIC W. WALFORD.

CHAPTER I.

CLEANLINESS.

ONE of the chief secrets in maintaining any mechanism in good working order is to keep it clean; and doubtless the perfect condition in which English locomotives are always to be found is responsible for their freedom from breakdown. It is probably more necessary to keep a motor car and its working parts clean than any other mechanism, on account of the conditions under which it works and to which it is exposed. There is probably no mechanism in use which operates under such adverse conditions. The motor car is exposed to dust, mud, and wet, and although the more delicate parts are enclosed, there are still many elements which require constant cleaning and attention.

Apart from the fact that cleaning in itself constitutes an examination of many of the parts, and frequently a loose nut, etc., can thus be discovered before any damage is done, cleanliness reduces the risk of failure, as it is obvious that no mechanism can work well when its parts are covered with dirt, and particularly road grit. Again, it is much easier to locate a trouble and to remedy it when the parts are all clean than when hidden under a coating of mud. Naturally, too, wear and tear are reduced considerably if dirt is washed off parts before it has a chance of working its way in.

Many a car is beautifully turned out with regard to its bodywork, but with its engine and transmission in a disgraceful condition. Such mechanism will wear out quicker and require overhaul far more frequently than that of a similar car in which the working parts are kept clean.

Dealing first with the cleaning of the bodywork, it must be remembered that the surface is a varnished one, and that, although varnish is hard, it will not withstand the abrasive action of dust and grit. A varnished surface must therefore never be rubbed if it is desired to keep the varnish in good condition. On completing a run the mud must be moistened with water, and before the actual cleaning is commenced it is well to direct the hose all over the body to prevent any of the mud drying to the varnish. Theoretically the mud should actually be removed by the stream of water, and if this can be done the varnish cannot possibly be scratched. In actual practice the mud will not all yield to the water stream, and it has to be removed with a sponge.

Some chauffeurs forcibly remove the mud with a sponge, dipping it from time to time in a bucket of water. This may be a quick way of cleaning, but a car so treated will look shabby in a few weeks' time. The secret of cleaning bodywork and keeping it in good condition is to use plenty of clean water and very little elbow grease. A sponge should therefore be lightly passed once over the bodywork under a stream of water from the hose. It is best, therefore, to hold the sponge in the right hand and the hose in the left, and make the hose do as much work as possible according to the consistency of the mud.

During washing it is naturally desirable that the water should be kept from contact with the engine, and care must be taken that this is the case. Particularly will water find its way through the air passages in the radiator and from underneath when the mudguards and wheels are being cleaned.

Having removed all the mud from the bodywork, it is then necessary to jack up each wheel in turn and deal with these in a similar manner, at the same time cleaning the tyres. The inside of the mudguard often presents a difficulty, and for these a hose and a good force of water are absolutely essential. The process of cleaning the inside of the mudguard generally causes considerable splashing, and it is often as well to clean these parts before the body itself is washed. Many chauffeurs start with the mudguards, then do the wheels, and finish with the body, giving a final quick wash all over. It is false economy not to provide oneself with a hose. It encourages laziness, and the finish is sure to suffer in a very little while. As soon as the finished surface is rubbed away, not only does the paintwork become dull, but it is impossible to keep the wet out, and the bodywork will start to rot and warp. If when the car is to be washed the mud is dried on, it must be thoroughly soaked before any attempt is made to remove it. For convenience in such cases, it is often customary to soak the bodywork and then to wash the mudguards and wheels, by which time the mud on the bodywork is sufficiently soft to come away fairly easily, and on no account should a brush or any petrol, paraffin, or soap be used on the varnish. If grease gets on to the bodywork, the grease spots can be removed with a little petrol or paraffin, which should be washed off immediately. Many chauffeurs mix petrol or paraffin with the water with which they clean either the whole car or only the wheels or axles, these being the parts which become splashed with oil or grease. This process cannot be recommended, and a car so washed soon looks dull. Mud should never be allowed to stay long on the bodywork, say during the night.

After the mud has been all removed the varnished surface must not be allowed to dry. For this reason the car should never be washed in the sun, as the water will dry quickly, leaving spots where each drop has dried. The varnished surfaces should be dried down with a moist chamois leather. This should be soaked in clean water and rinsed out a number of times before using. It should then be wrung to squeeze out the water, and then rubbed over the bodywork so as to soak up the water on the varnish. After each panel has been dried in this manner the leather should be rinsed out, the water in which it is rinsed being changed from time to time. The bright metalwork on the radiator, lamps, etc., can be dried with a moist chamois leather ready for a proper polishing. Brass polish will not work properly on a wet surface, so that all parts to be subsequently polished must be carefully dried.

Various compounds are advertised for improving varnished surfaces after washing. Of these the author has had no experience. Such as are of a sticky nature would probably pick up and hold dust, and should be avoided.

Cleaning the bright metal surfaces, such as the radiator, lamps, etc., is not difficult ; they should be well dried and the polishing mixture well rubbed on to the metal and allowed to dry or not, according to the material used, and then polished up. Some polishing mixtures attack varnish.

Rubber-covered floorboards will clean up splendidly if scrubbed with a nailbrush and soap. The leather upholstery requires cleaning from time to time, especially the recesses in which lie the upholstery buttons.

Wind screens at first attempt seem somewhat difficult to clean. They require well washing, drying with a chamois leather in the same way as a varnished surface, and then rubbing over with a ball of wet newspaper. This puts a finish on the glass which cannot be obtained with chamois leather only. It will be found that little bits of paper will probably adhere to the glass in places. A few minutes afterwards these can be dusted off.

Cape cart hoods often become very muddy. They present no difficulty in cleaning. They require merely washing and exposure so as to be allowed to dry quickly. If packed away wet deterioration is encouraged.

The above description has referred chiefly to the cleaning of a muddy car, and it is to be understood that the same process is required with a car merely dust covered. Dust should never be wiped off dry from a varnished surface. The dust for the most part is very fine road grit, and its removal in this manner obviously scratches the varnish. It may seem almost a waste of labour to spend almost as much time washing down a car when it is only slightly dust covered as is necessary for one covered with mud. The presence of dust on really dry varnish probably does little or no harm provided it is not touched, but a dusty panel is an inducement to street urchins to inscribe their names upon it, whilst it is very difficult to avoid touching the varnished surfaces and causing slight damage to the varnish. The simplest remedy is to have the car painted French grey or some similar light colour which does not show the dust. For the man of moderate means who does not keep a chauffeur, and has to do his own cleaning, these light colours are a considerable saving, as the presence of a fine coating of dust is hardly noticeable, and there is no necessity for washing the car every day when on tour. This fact accounts for the popularity of light colours such as French grey on small cars.

The removal of tar stains is a matter of some difficulty, as they are unaffected by petrol or water. They will, however, yield to butter and also to methylated chloroform. The chloroform must be handled carefully, otherwise it will affect the varnish. A drop must be put on each tar spot, and a small piece of rag soaked in it, and then used to pick off the tar spot. The rag must not come into contact with the varnished surface more than can be helped, and the surface must not be rubbed. The chloroform should be first used on some unexposed part of the car, so that the user can ascertain what effect it has.

Cleaning the Engine and Transmission.

The modern engine does, and all engines should, keep very clean. The modern practice of enclosing the valves certainly tends to keep the sides of the crank chamber very much cleaner than used to be the case, and it should be a matter of pride to every motorist to keep his engine clean, as well as in good running order.

The actual process is not a difficult one. A tray to hold paraffin and a brush will remove all the oil and grease, whilst a final rub over with a rag moistened with petrol, or petrol brushed over it, will remove all traces of paraffin.

If oil is found to make its way through any particular joint, such as the lid of the gear box, this joint should be provided with a suitable washer. If one is provided by the makers it should be seen that it is not torn, and if no washer is provided one should be cut from thick brown paper soaked in boiled oil or gold size. The former is merely linseed oil boiled until it is slightly thicker than treacle. The surfaces should be cleaned before the joint is applied. Boiled oil should never be put on the valve cap threads, as if this is done it will be found impossible to remove the caps subsequently. The oil can be put on the face of the valve caps, but at this point the joint should be maintained by proper copper washers, which can be obtained from the engine makers.

The painted parts of the engine should be rubbed over with an oily rag, and the bright metal parts cleaned with any brass polishing mixture such as is used for the radiator and lamps.

The flywheel is sometimes found to throw oil. This is sometimes due to an adjacent oil pipe leaking slightly at a joint, or to the oil exuding from the back bearing of the crank chamber, also to the lubricant getting out of the clutch bearing. Further, if the undershield has not been cleaned for a considerable time, there might be such an accumulation of grease in it as actually to touch the flywheel. For the back axle a bucket of water with a little paraffin in it and a spoke brush are all that are necessary, the amount of paraffin varying with the amount of oil and grease on the axle.

CHAPTER II.

THE ENGINE.

IT is often assumed that when an engine is new it gives its maximum power, but in actuality this is not the case. At the outset the bearings are tight and the bearing surfaces comparatively rough, and it is not until the engine has run some months that the highest power is developed. It is not to be assumed that up to this period the engine gradually increases in power, but that a higher power *can* be obtained from an engine after being well run in than when it is new.

In actual practice the engine gradually gives less and less power unless it receives the necessary small amount of attention to keep it up to its best pitch. The cause of this is a gradual loss of compression, chiefly owing to the burning away or pitting of the valves and their seats, the remedy for which is regrinding. Valve-grinding is a somewhat laborious process, but it is one which generally effects considerable improvement in the engine's running, and it should be made a periodic practice, and not be left till the engine is running very badly, as the necessary grinding will then be somewhat difficult.

If a valve is examined it will be found that it has a flat angular surface on the underside of the head, and this surface rests upon a similar conical surface, called the valve seat, formed in the cylinder head. These two surfaces must be absolutely true and smooth so as to prevent any gas leakages when the valve is closed by the valve spring.

When the exhaust valve is opened the exhaust gas, which is an intensely hot flame, passes between these two conical surfaces, making them practically red hot, which is their normal condition during running of the engine. It is hardly surprising, therefore, that in course of time the surfaces deteriorate, and the necessity for regrinding can be ascertained from an inspection of the valve and its seat. If smooth and bright all round, the valve is in good order. If dirty and rough, it requires regrinding. When loss of power is experienced, to ascertain if it is due to loss of compression, the engine should be turned round slowly, with the switch off, and if the resistance on the compression stroke is not what it was when the engine was new, it is clear that there is a leakage somewhere, and the exhaust valve should then be examined as mentioned. Possibly only one or two of the valves are at fault, so the compression in each cylinder in turn should be tested in this way.

Before a valve is ground in it is, of course, necessary to remove it, and this, with its replacement, forms probably the most difficult part of valve grinding, on account of the stiffness of the valve spring, coupled with the fact that the parts are generally difficult of access, on account of the presence of the piping, etc.

Fig. 1 is a sectional view through a valve chamber, and reference will be had to it in the following description: The first step is to remove the valve cap, which is inserted in the screwed opening A, and frequently fitted with a compression tap. Immediately opposite the opening A will be seen the head B of the exhaust valve. If a spare exhaust valve spring, cotter, and washer can be examined, the procedure about to be described will be more readily understood, but these parts will be found illustrated in fig. 2. For the sake of clearness the various parts are shown separated. First there is the valve stem C (figs. 1 and 2), which latter is formed with a slot at D. Into this slot slips a cotter E, which is a usually small flat bar. Sometimes this is round, and in the case of the White and Poppe engines, instead of being inserted vertically, it is slotted and slipped into a groove on the end of the valve stem. Threaded on the end of the valve stem is a washer or cup F, which is shown cut in half to illustrate its inverted cup shape. Above these, and also threaded around the valve stem, is the spring G. When the parts are assembled they take the relative positions shown in fig. 1, and the spring on the one hand presses against the valve guide H or cylinder, whilst its lower end rests upon the cup-shaped washer F, pressing it down on to the cotter D, which is prevented from sliding out of the slot by the fact that it lies within the cup-shaped washer.

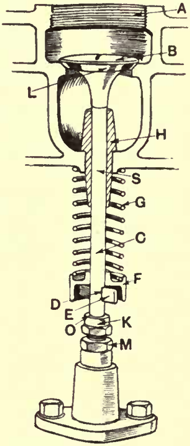

FIG. 1.—Sectional view showing mushroom valve in position.

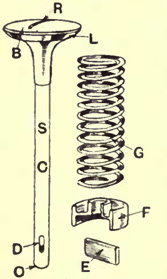

FIG. 2
View of valve, parts separated.

Now to remove the valve it is necessary to raise the washer F so as to expose the cotter E and allow the latter to be withdrawn. There is then nothing to prevent the valve B being pulled up through the opening A. This process seems very simple, but, as stated, it is attended with some difficulty. To cope with this there are on the market various valve spring compressing tools which suit various engines. It is well to ascertain from the makers of the engine if a special tool is made by them to fit their engines, or if they can recommend some tool on the market which will be effective.

Fig. 3 is a sketch showing a simple tool for this purpose which can be constructed by most mechanics. When an attempt to lift the valve spring is made it is generally found that the valve rises with the spring unless a tool such as that shown in fig. 3 is used, and to prevent this in other cases it is convenient to place on the valve head B a block of wood or some similar distance piece and then screw down the valve cap into the opening A so as to press on the distance piece and prevent the valve rising. Both hands are then left free, one to compress the spring and the other to pull out the cotter. Fig. 4 shows this, and also the operation of a valve-lifting tool of another type.

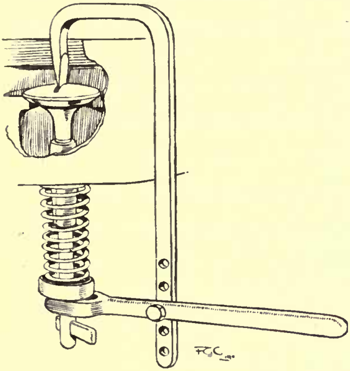

Fig. 3.—A simple valve-removing tool in operation.

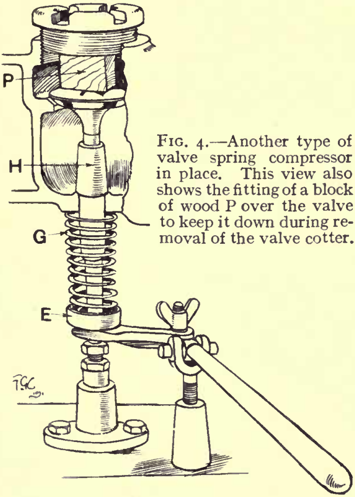

Fig. 4.—Another type of valve spring compressor in place. This view also shows the fitting of a block of wood P over the valve to keep it down during removal of the valve cotter.

Having removed the cotter, the valve cap and the wooden distance piece P (fig. 4) can be removed and the valve drawn upwards. Sometimes the valve sticks slightly, owing to its bottom end having become blurred over at O (figs. 1 and 2). If a reasonable amount of force does not cause the valve to come away, the lower edge at O should be slightly trimmed with a file. Sometimes the edges of the cotter slot D (fig. 2) burr over, and this should be looked to. If this does not allow the valve to be freed easily, it may be deemed that the valve is slightly bent, and when removed it should be carefully examined to see if this is the case.

Assuming the valve now to be taken away, the spring and cotter can easily be removed ready for the actual operation of valve grinding.

Before commencing the actual grinding it is necessary to see that the valve stem C does not make contact with the valve tappet K (fig. 1), as otherwise no amount of grinding pressure will bring the valve surfaces into contact with one another. If the valve stem does touch the tappet K, the locknut must be slacked and the tappet screwed down, or a small amount filed off the foot of the valve. For the former, it is first necessary to slack off the locknut M (fig. 1), after which the tappet K can be screwed down quite easily.

The actual grinding-in consists in applying to the conical surface, *i.e.*, to the face L (figs. 1 and 2), a mixture of emery and oil, or carborundum powder and oil, or some special grinding mixture, and then putting the valve in place in the engine (without the spring) and working it backwards and forwards rotatively, so that the grinding mixture sets up an abrasive action, grinding down both surfaces smooth.

The best method of applying the mixture is to put a drop of oil on the valve face L (figs. 1 and 2) and then smear it round, and next dip a finger into the emery powder and coat the oil with emery. A further application of oil is then advisable. To improve the cut, paraffin may be used for the second application, and in any case it is advisable to have the mixture very moist. If dry, the composition will merely roll, and not cut.

The valve so treated is then put into place (without the spring and washer F) and moved either round and round or backwards and forwards, preferably the latter. For this purpose the valve head is provided with a saw cut R (fig. 2) to receive the end of a screwdriver (fig. 5). In a very short time it will be found that the process is a tiring one, and to render it somewhat easier it is best to obtain a brace or low-geared drill and put in its chuck a turnscrew or screwdriver bit. If the valve is rotated continuously in one direction by means of the brace the result will be to cut circular rings on the valve face, which is detrimental. It is therefore advisable to give one or more turns in each direction alternately, and now and then to lift the valve from its seating so as to allow the mixture on the surface L to change its position. This prevents over-grinding at one place and ensures the mixture being properly spread out. To facilitate lifting of the valve, a good tip is to obtain a short spring and insert it under the valve head, as shown in fig. 5. This spring should be sufficiently long and stiff to keep the valve normally away from the seat, as the illustration shows, so that directly pressure is removed from the screwdriver or brace the valve automatically rises. The valve should then be turned into a fresh position before grinding is continued.

From time to time the valve should be removed and perhaps a little more oil put on the valve surface L or more mixture. The oil usually employed is a somewhat thin one, but engine oil will do if thinned with paraffin. Grinding should be continued until both surfaces are perfectly smooth and unmarked. At first it will be found that the surfaces are covered with black spots. These should be ground right away before the valve is finally replaced.

It will be gathered that during grinding there is considerable risk of some of the abrasive mixture finding its way into the cylinder. This should be prevented, which can be done by the exercise of care or by inserting a rag into the passage between the valve and the cylinder before the actual grinding is started.

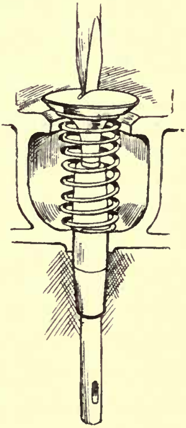

FIG. 5.
A light spring should be placed under the valve so as to lift the valve when required.

After the valve is ground in the spring (shown in fig. 5) should be removed and the adjacent parts thoroughly cleaned to remove all emery and oil. The valve can now be put back, the spring G and washer F being first put into place. These latter must be raised, repeating the process described in connection with the removal of the valve, in order to allow the cotter E to be put into place. In the replacement of these parts the valve spring tools, shown in figs. 3 and 4, are of just as much use as during the removal of the valve. Before the valve is actually put into position it is a good plan to rub the stem at S (figs. 1 and 2) below the valve head with graphite, which is a good lubricant, and reduces wear on the stem at the point where it passes through the valve guide H (fig. 1).

Owing to the fact that the inlet valve is not subjected to the temperatures which the exhaust valve reaches, it is very rarely necessary to grind it in. The period at which valve grinding becomes necessary varies with different engines and the care of driving, etc. Roughly, with a water-cooled engine, the exhaust valve should be ground in after 3,000 miles and the inlet after 6,000. No harm can be done by grinding in a valve, so that if an engine loses power before it has run this distance it is well to examine the valves and give them a slight grinding. After the valve is replaced the cotter K (fig. 1) should be readjusted, and locked by means of the nut M.

If a valve is badly burnt examination will show whether it is better to fit a new valve rather than grind in the old one. Very often a badly burnt valve can be recut and trued, and to replace the whole process of valve grinding, a process of valve truing and an apparatus for carrying it out has been evolved by the Southern Automobiles, Ltd. The apparatus consists of a pair of cutters, one of which recuts the valve face after it has been removed, whilst the other has the same effect on the valve seating. Into the respective merits of the two processes it is not proposed to enter, but valve grinding is the more common practice, and it can be applied not only to the main engine valves, but to other valves when the need arises. Thus a petrol or water tap sometimes leaks slightly, when it should be removed and the removable part ground in with some fine emery powder.

It will have been gathered that grinding-in of valves is done to restore loss of compression, but this weakness is sometimes due to other causes. For instance, any one of the cylinder joints may be leaking. The sparking plug washer and that upon the valve cap which screws into the opening A (fig. 1) sometimes leak, and to ascertain if this is the case some paraffin should be squirted round these washers and the engine turned round just to come on to the compression stroke. When pulled slowly over the compression stroke the presence of bubbles will indicate if there is any leakage at these points. If there is leakage new washers must be used. On no account should any adhesive mixture, such as boiled oil or gold size, be put on the screw threads. This is sometimes done to obtain good compression, but it is inadvisable, on account of the extreme difficulty in separating the parts later.

Loss of compression is also due to wear set up between the piston and cylinder. In engines that have done a considerable amount of running the cylinders may have worn slightly oval, and they should be carefully examined to see if this is the case, and if so, should be rebored. The trouble is usually, however, confined to the piston rings, and new rings are generally required on a water-cooled engine after 10,000 to 20,000 miles. In good engines carefully looked after perhaps they will not be necessary until 30,000 miles have been run. To fit new rings is, though not a difficult matter, one that requires a certain amount of care. It is very easy to put a ring into the top slot, but to get it into one of the middle ones is not so easy. To do so the adjacent grooves should be temporarily filled up with some packing or, what is better, some strips of sheet metal or whalebone should be employed, as shown in fig. 6, and the ring slid over these until the proper groove is reached. These strips will prevent the ring from fouling the adjacent groove. Each ring after being in use must be bright the whole way round; if this is not the case it shows that contact is not made throughout the whole length of the ring, and a new ring should be fitted. Piston rings should fit comparatively tightly in the grooves, and when compressed so as to lie nearly flush with the piston the slots should be closed. The weak point in piston rings, as regards holding compression, is the slot, as a slight leakage is bound to take place along it. Consequently when two or more rings are fitted the slots should be arranged alternately on opposite sides of the piston, so that as long a path as possible is made for the escaping gas and leakage reduced. Thus when the cylinders are removed care should be taken to turn the piston rings into this position. In some cases the piston rings are pegged to prevent their taking up wrong positions.

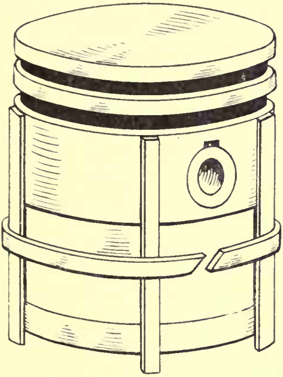

FIG. 6.—Piston rings fitted with the aid of strips.

After a water-cooled engine has run a considerable distance, say anything from 5,000 to 10,000 miles, it may be found that power is falling off, in spite of the compression being good, that when going up a hill with the throttle wide open the engine knocks and does not seem to run so well as when new, or that the engine preignites or continues to run when switched off. These are definite signs that the inside of the cylinders and the piston heads require cleaning.

In the course of running soot is formed in the engine, the quantity varying with the richness of the mixture and the facility for the lubricating oil to get past the piston. This carbonaceous deposit, combined with the non-inflammable constituents of road dust which are sucked through the carburetter, adheres to the cylinder walls and combustion head, causing falling off of power, and in time preignition. When the valve cap fitted at A in fig. 1 is removed it will be found that its underside is coated with soot, and sometimes even with a hard deposit, an indication of the state of the interior of the cylinder. To remove this carbon deposit, the usual procedure is to take off the cylinder so as to expose the parts and scratch off the deposit with a screwdriver or some similar instrument. From the tops of the piston the deposit can be cut away with a knife, and when removed the surfaces should be polished with fine emery cloth, as deposit adheres less easily to a polished surface. The deposit must be completely removed from all parts of the cylinder as well as the piston, a matter of some difficulty.

There have been one or two inventions evolved from time to time to remove the deposit without necessitating the dismantling of the engine. One of these is to insert a steel ball about ½in. in diameter into the cylinder and then to run the engine, its action being to hammer the carbon deposit and so chip it off the surface. Another, and more promising, process consists in passing a stream of oxygen into the cylinder, lighting it, and so causing a chemical combination to take place between the carbon and the oxygen. As soon as all the carbon has combined the flame goes out, and it is known that the cylinder is clean. The writer has not tried either of these schemes, but mentions them as matters of interest. The ball process, however, would seem rather risky.

To keep an engine in good running order the valves, apart from grinding-in, require careful attention. In the olden days silence of running was not of great importance, but nowadays it is an essential, and to obtain it one of the most important points is to see that the clearance between the valve tappet K (fig. 1) and the bottom of the valve stem is small. As the engine runs it will be understood that the tappet K rises rapidly and strikes the foot of the valve. If there is a large clearance between these two the impact between the tappet and the valve causes a clicking noise, which should be stopped by adjusting the tappet head close up to the valve stem. The usual distance or clearance is about $\frac{1}{50}$in., being about the thickness of a visiting card. On modern engines the top of the tappet head is inlaid with fibre to reduce the noise, and in course of time this fibre becomes dented or recessed. The tappet should then be removed and its head filed flush so as to remove the dent.

If the engine is not fitted with adjustable tappets a simple substitute can be constructed, as shown in fig. 7. Here the foot of the valve stem, shown at A, is being actuated by the tappet B. Above the tappet is slid a tube C, the end of the tube resting on the tappet head B and enclosing the fibre washers D. These prevent noise, and by varying the number of washers used in each case a simple means of adjustment is provided. If it is thought advisable to lengthen the valve stem at any time the foot can be drilled and tapped and a small set screw inserted, as shown in fig. 8. The head of this set screw can be filed off so as to bring the valve to the required length.

Fig. 7 also shows a simple means for utilising a valve which has broken off at the cotter hole, and is consequently not long enough to reach to the tappet head. A new cotter hole should be made and the space between the stem and the tappet filled up with washers, as shown at D. A broken valve can often be caused to operate automatically, provided a mechanically operated inlet valve is used. Assuming that it is an exhaust valve, fig. 9, that has broken at the cotter hole, and no spare is to hand, it should be removed and the mechanical inlet valve should be put in its place. The defective exhaust valve should then be drilled as at A to form a cotter hole and inserted in the place of the original inlet valve. The inlet valve spring originally used is far too stiff to allow the temporary inlet valve to open automatically, and consequently a spring of much smaller resistance must be

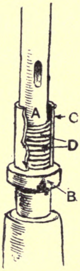

Fig. 7.—How to take up slack in the tappets when no adjustment is provided.

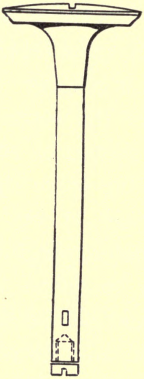

Fig. 8.—A simple method of lengthening the valve stem.

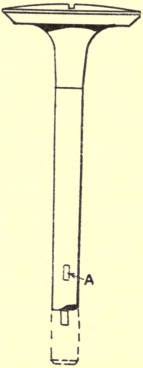

Fig. 9.—A broken exhaust valve.

obtained and used in the ordinary manner. It will be understood that the valve stem will not reach down to the tappet, but that on each suction stroke of the engine the valve will be sucked open, allowing the gas to enter the cylinder, and will close automatically at end of the stroke.

On some engines it is possible, when a valve breaks, for the broken head to enter the cylinder, and perhaps do a large amount of damage in a short time. To remove the valve head it is probably necessary to take off the cylinder, but an attempt should be made with a small magnet on the end of string to draw the head out without going to this trouble.

As stated in reference to the presence of carbon deposit, an engine will sometimes develop a thumping or knocking noise up a hill. Another cause of this is early ignition, either due to the magneto being set to fire rather early or to the hand control ignition advance not being manipulated properly. The ignition should, of course, be retarded on a hill, and if this does not remove the knocking or thumping, the driver should make quite certain that his engine is cooling properly, and if the cylinders have not been cleaned for a considerable time, they should be dismantled and the carbon deposit removed as described. Frequently one of the sparking plugs causes preignition and knocking, and it is well to try a different set of sparking plugs as experiment. If the engine is an old one, and the above suggestions do not produce a cure, it is probable that the main bearings are worn, chiefly those of the connecting rod and crankshaft bearings. This is a job for the makers or for some capable repairer. In general, the running of an engine with a slight amount of bearing shake is not very detrimental, and for hill-climbs and other tests where maximum power is required it is usual to provide bearings with some considerable clearance to reduce friction as much as possible.

Sometimes knocking is due to the cylinder holding-down bolts being loose, or to some fault in the universal joints in the transmission. A very big gap between the valve and its tappet will cause a clicking noise, as also will a loose magneto, or pump, coupling.

An engine may suddenly pull up, and it be found impossible to turn the crankshaft with the starting handle. The popular expression for this is "seizing." It is not a correct term, but it is good enough for its purpose. By way of explanation, it should be stated that for a shaft to run continually in a bearing, or piston in a cylinder, there must be a film of oil present between the shaft and its bearing, otherwise excessive heat will be set up, causing undue expansion of the metal parts, and also, if the heat is sufficient, a change in the characteristics of the metal itself. If the latter case does not arise the metal parts will merely bind so tight, due to the expansion of the shaft, that the shaft will jam, and this is usually the condition which occurs in an engine. Sometimes it is the piston which seizes in this manner, but in extreme cases the seizure is so bad that the metal surfaces actually run together and the parts are practically done for. In the event of the engine jamming in this manner, the procedure is to allow the parts to cool down, which may be assisted by running off the hot water in the radiator and filling up with cold water, and to inject a copious supply of oil to the seized part. Of course, it is not always easy to ascertain whether it is a bearing or the piston that has seized, and which particular one in a multi-cylinder engine.

but a large charge of oil should be admitted to the crank chamber, and a little paraffin mixed with engine oil squirted into each cylinder. When the parts are cool the engine should be forced round gently with the starting handle, the compression taps being open or the sparking plugs removed. Generally this process will gradually free the bearing and allow the engine to be rotated fast by hand. Careful attention must be paid to the lubrication before the engine is run again on its own power, and it should not be given any hard work to do, and should be stopped every mile or so until the cause of the seizing is ascertained and corrected. Possibly it is due to running short of lubricant, to the oil having escaped from the crank chamber, to one of the oil pipes being choked up, or to one of the bearing bushes having turned round slightly so that it cannot receive any oil through the hole in it provided for that purpose.

In the event of an extreme seizure, it is rarely that anything can be done except to replace the seized parts, which is work which should be entrusted to the makers if possible.

Sometimes an engine will jam in the manner described due to some derangement of the clutch or the coupling between the clutch and the gear box. If the engine is not a new one, and if everything seems all right, it is very unlikely that the seizure is due to lack of lubricant, in which case considerable time can often be saved by inspecting the clutch and its coupling. Sometimes a broken piston ring or some similar accident to the engine will cause it to jam, giving one the impression that a bearing has seized. It must not be supposed that seizing is a common event. It is one of the most uncommon, but it is one which may be serious, and therefore deserves mention.

CHAPTER III.

IGNITION.

THE ignition system used at first to be responsible for most of the smaller troubles with which motorists had to contend, with the result that electricians gave it their special attention and perfected the "magneto" system, which has done away with most of the troubles which used to occur.

The Accumulator System.

There are, however, very many cars running at present fitted with the accumulator system of firing, so that it is necessary to explain the troubles to which it is liable and the various faults which may occur.

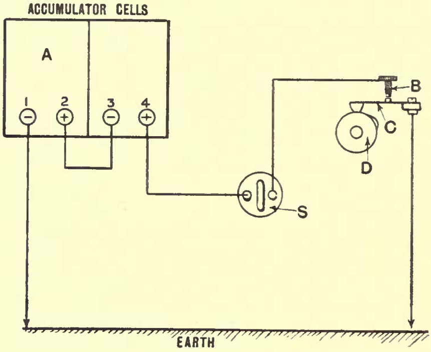

FIG. 10.
Diagram of primary winding with coil omitted.

It is often thought that there is a great deal of special knowledge required to understand electrical matters; this does not apply, however, to the simple electrical fitments used on a motor car. Common intelligence is quite sufficient, and special training in electricity is by no means necessary.

Each accumulator employed in accumulator ignition systems comprises two cells joined together and each having two terminals. Thus one of the cells, fig. 10, is provided with terminals here marked 1 and 2 and the other with terminals 3 and 4. The odd numbers are assumed to be the negative terminals and numbers 2 and 4 the positive.

Each complete fully charged cell gives 2.2 volts when tested with a voltmeter, the voltage falling as the charge is gradually used up, and such a test is a rough one to ascertain the amount of current in the accumulator. It is not an accurate test, but it is an easy one, and if the accumulator is tested at the end of a run it is a very good test. Accumulators have the power of recuperation, so that after standing for a night a weak accumulator will show full voltage and yet fail after a few minutes' running. If on testing the accumulator, by touching with the voltmeter wires the terminals 1 and 4 (which are the ones to which the ignition wires are attached), a reading of anything over 4 volts is obtained, it is known that the accumulator contains a good charge. If it shows less, it is not quite up to its proper condition, and either wants charging at once or shortly after, according to the reading obtained. As soon as the voltage falls to 3.6 it may be taken that the accumulator will do very little more work. To coax a little more current out of an accumulator, it may be immersed almost up to the top in boiling water, which sometimes has some effect in livening it up. Further, a number of partly run-down accumulators may be coupled up until a voltage of 4.5 is obtained.

If on testing an accumulator it is found that the voltage between the terminals 1 and 4 is only 2.2 volts, suspicion must be cast on one-half of the accumulator only, and a test should then be made between the terminals 1 and 2 and between 3 and 4 separately. Two readings are then taken, one from each cell, and it will probably be found that one cell is up to its full voltage, *i.e.*, 2.2, and the other shows little or nothing. This means that one of the cells has either been short-circuited or has broken down inside. The defective cell should then be disconnected and the good one used, wired up to another if necessary. Of course, if another 4-volt accumulator is to hand it is more convenient to use this alone, but if the stand-by accumulator is partly run down, the sound half of the original accumulator can be coupled to it, coupling up the positive terminal of one accumulator to the negative one of the other. There is no harm in using a slightly higher voltage than 4, but it is advisable not to use as much as 8 volts, as it is liable to strain the ignition coil, whilst little or no advantage is obtained from using so high a voltage.

Regarding the troubles which may affect the supposed defective cell, the chief of these is wastage of acid. Accumulator cases are made of celluloid and are somewhat delicate, and it is obvious, if a case springs a leak and the acid gets away, that cell will give no more current. To repair the casing a mixture should be made of a few strips of celluloid, such as chips of old photographic films, dissolved in acetone. This solution is adhesive, and a patch of celluloid strip can be applied to stop the leak, or a joint can be made of the acetone alone if the crack is only a small one. Another cause is due to the lead paste, which is the active material in the accumulator, dropping down and short-circuiting the plates. Or a terminal or some other part of the accumulator plate may have broken. In such cases it is best to send the complete accumulator to a capable repairer, as accumulator repairs, which, fortunately, are not often necessary, are outside the capability of the average motorist, and special knowledge and materials are required.

Going back to the voltmeter test, if the whole accumulator gives 2.2 volts reading or approximately so, and if on testing each half of the accumulator separately a reading of about 1 volt is obtained, it is highly probable that a leak has occurred *between* the two compartments, and instead of there being, properly speaking, two cells, the acid between the two compartments is in communication, and the result is, electrically, one cell of large capacity giving 2.2 volts. To ascertain if this is the case, examination should be made of the acid level in the two compartments. If not the same, it is obvious that this cannot be the case, but if it is exactly the same, a little should be emptied from one of the accumulators, and the accumulator allowed to stand to make certain that there is a leak, in which case the level would, of course, shortly reach the same height in both cells. The repair in this case is also one which should be dealt with by a repairer or an electrician, as it involves dividing the accumulator, repairing the leak, and making a fresh joint.

From time to time accumulators require washing out, for which purpose the plates are removed from the casing and completely cleaned and the plates washed. This again is a repairer's job. Occasionally also it is necessary to fill up with fresh acid solution. The acid consists of pure sulphuric mixed with distilled water in the proportions of one volume of acid to four times that amount of water. The water should be put into a jug of sufficient capacity to receive the added acid, which should be poured in slowly, the mixture being stirred meanwhile with a glass rod. If the water is added to the acid the mixture will boil and splash over. The acid mixture is, of course, a violent corrosive, and should be handled very carefully.

The chief antidote to acid splashes is ammonia solution. Almost every accumulator will splash slightly, especially on a motor bicycle, and such splashes will affect neighbouring parts, such as the wiring and boxes. A good tip is to put some sodium bicarbonate, which is a clean white powder, into the accumulator box. This will immediately neutralise any acid which is splashed over.

An accumulator will sometimes sulphate, the communication to the user being failure to do a proper amount of work, and consequent running-down quicker than usual. This is due generally to improper charging or to allowing the plates to remain dry. Excessive or insufficient charging current will cause "sulphating," as also will too weak electrolyte or acid solution. When getting the accumulators charged the electrician's attention should be called to the supposed sulphating, and he should then charge the cells correctly, which gradually has the effect of removing the "sulphate." Slight sulphate can be reduced by putting a teaspoonful of washing soda into each cell and then charging for about six hours. The sulphate then disappears, when the solution should be washed out and the cell refilled with fresh solution and recharged.

It will be gathered that an accumulator is a delicate article, and should be carefully handled. It should never be lifted by the terminals, and should always be kept full of acid up to the top of the plates. The top of the case and the terminals should be kept clean. The latter will require coating with vaseline to prevent corrosion. Sometimes this corrosion fixes one of the terminals so tightly that it cannot be unscrewed. In such cases the application of heat to the terminals causes it to come away quite easily, especially if a drop or two of ammonia be applied first to the terminal.

The accumulators are coupled by wires to the various parts, and these parts are variously arranged on different cars. Usually one of the terminals is connected direct to "earth" or the metal frame of the engine or car either through the medium of a switch or not, as the case may be. Thus in fig. 10 the terminal 1 is shown directly connected, and the wire attached to terminal 4 passes through a switch S. The current passing through the switch goes to the insulated contact screw B or the equivalent on the contact breaker. Contact is made with this screw by means of the blade C, which is actuated by the cam D on the engine or valveshaft. The contact points of the screw B and the blade C are made of platinum, and it is absolutely essential for good working of this ignition system that these platinum surfaces be *clean and smooth and meet one another squarely*. Unless the contacts come together flat they give trouble in a short time, and these contacts are responsible for a large proportion of the misfiring troubles which occur. To test this system the switch should be put in the "on" position and the engine turned round slowly, so that the blade C is pushed up against the contact screw B. When the blade falls away from the screw it should be noted if a small spark occurs at the platinum surfaces. If it does, the probability is that the ignition system, as far as already explained, is all in order. If it does not, the platinum points probably require cleaning or the screw B wants adjusting a little closer to the blade. If this does not remedy matters the accumulator should be tested and the terminals and various wires examined to see if any of these are loose, and very frequently one of the many terminals necessary to the accumulator system is loose, causing erratic working.

It should be seen that the insulation of the wires is in good order and the switch definitely "on." If all these points are attended to, the primary system, that is to say, the ignition system, so far as described, is all in order.

In the foregoing description we have omitted all reference to the coil in order more completely to separate the primary and secondary systems. Fig. 11 shows a coil duly wired up. The coil in question is of the non-trembler type, and the contact breaker shown in fig. 10 is of the make and break type, the trembler type of coil and the wipe contact system being explained later.

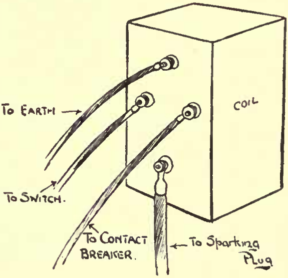

Fig. 11.—The wiring of a single-cylinder coil.

With a plain coil, as shown in fig. 11, one of the wires is either connected to the switch or to one of the terminals on the battery, according to the marking. Another is coupled by an insulated wire at the contact breaker screw, whilst the third of the smaller terminals is connected to "earth," which is represented by the shaded lines. The larger terminal shown arranged by itself at the other end of the coil is connected to the sparking plug. With a make and break contact breaker it is necessary to provide an extra "earth wire," which is connected to the central terminal fig. 11, and is used for the secondary current.

A coil of this nature is extremely simple, and gives little or no trouble. It requires attention from time to time to see that the terminals are tight, and it must be kept dry. There are a large number of different patterns of plain coil in use, and the terminals are often coupled up in a different manner, but in most cases they are plainly marked. Sometimes terminals are marked by letters only, and in such cases the letters M or E usually indicate the "earth" terminals, C the contact breaker one, and B the terminal which is to be connected to the sparking plug. The make and break contact breaker depends for efficiency of its operation on clean contacts and a quick break after the platinum points have been brought together. A coil should not be exposed to great heat or to damp.

As will have been gathered, in place of the make and break contact breaker a different system is often adopted. This comprises in its simplest form a vulcanite disc A (fig. 12) fixed to the spindle B. The disc is of vulcanised fibre or other insulating material, and it is provided with a segment or block C of brass or other conducting substance, which passes right through the block A so as to touch the shaft B. On the edge of the disc A rests a blade D, to which the wire from the coil is attached. It will be gathered that so long as the blade is resting on the insulated part A no current passes, but that when the block A is rotated by the engine the current passes along the blade D to the block C, and so to the shaft B. The shaft B being, of course, in contact with the engine bearings, etc., the current is consequently "earthed."

This term "earthed," rather an inappropriate term as applied to motor vehicles, possibly requires some explanation. It is probably understood by the reader that in all electrical systems the electric current has, as it were, to make an out and return journey, doing its work on the way. For the return journey, to save unnecessary wiring, the current is allowed to flow through the frame of the engine or car, and two wires are for this purpose connected to the framework. This return is called the "earth" return.

Examining fig. 10, it will be seen that the current is allowed to run along the shaded line marked "earth," but it is obvious that the wires which run down to this shaded line could be connected together, in which case there would be no "earth return." Using an "earthed" return, however, simplifies matters, and is usual.

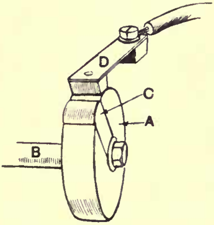

FIG. 12.—View of a very simple type of "wipe" contact breaker.

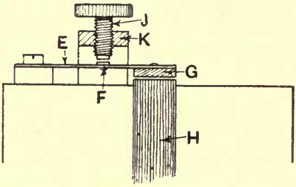

FIG. 13.—Sectional view of coil showing trembler and core only. Winding not shown.

Referring to fig. 12, it will be seen that as soon as the electric current can flow to the shaft B it is earthed and the circuit completed. With this type of contact breaker it is merely necessary to keep the parts clean. Very often they require to run in oil, whilst in other cases they have to be used dry, according to the make of contact breaker. The segment C should stand up slightly higher than the edge of the block A, and in course of time the end of the blade D wears away and requires renewal, and sometimes chips get into the contact breaker, so that an occasional clean out has a good effect.

The ignition coil used in conjunction with the wipe system, in contradistinction to the simple construction shown in fig. 11, is provided with a trembler, which is a delicate device, and one which requires frequent attention. This is represented in simple form in fig. 13.

This trembler is mounted upon the top of the coil, and it can be exposed by removing the lid of the coil. It comprises a spring blade E carrying at F a platinum contact block and at G a disc, called the armature. This comes immediately opposite the bundle of wires H which passes down the centre of the coil, and is termed the core. When the current passes through the coil the consequent magnetisation of the core H attracts the disc G, pulling down the blade E. Above the contact block F is a contact screw J, which is tipped with platinum, and is adjustable in its support or bridge K. In operation the blade E vibrates backwards and forwards extremely rapidly, causing the platinum contacts to touch and then to break apart, subsequently touching and breaking again so long as the circuit is closed, which is dependent upon the contact breaker, fig. 12.

Here again the platinum contacts must be perfectly clean, and from time to time require filing slightly with a very fine file and readjusting. The latter operation is a very simple one, and consists merely in turning the engine so that the contact segment C (fig. 12) is underneath the blade D. The switch should then be put in the "on" position and the screw J (fig. 13) tightened up until the coil starts to buzz.

The contacts should not be adjusted together too tightly, otherwise the blade E becomes slightly bent, and it should be noted that it should be perfectly straight.

Platinum is a very expensive metal, more costly than gold, so that filing or trimming of the contacts should be done carefully. The best way to trim a platinum contact without wasting metal is to tap it slightly with a hammer, which flattens the surface, and then to polish it flat with a matchbox surface.

The terminals on the trembler type of coil are coupled up in the same manner as those of the plain coil, fig. 11, except that in the former case there is no "earth" terminal to be connected. In both types of coil the thick high tension wire is taken to the sparking plug. The latter gives a certain amount of trouble, and a spare should consequently always be carried, preferably packed in a box to prevent damage.

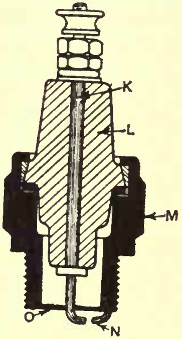

FIG. 14.—A sparking plug in section.

The sparking plug is a very simple device, as will be seen from fig. 14. It merely comprises a central wire K passing through an insulating block or tube L, which is either in one or two pieces, according to the type of plug employed. This block is fixed into the metal body M, which has attached to it a projecting wire N, the end of which lies close to the end of the wire K, a small space or gap being left between the ends of the two wires. As the reader will have understood, ignition takes place when the electric current jumps from the end of the wire K across this gap to the wire N, and so to the body M, which, being screwed into the engine, is "earthed." The current then returns to the coil by means of the earth wire, fig. 11. In the case of a trembler coil a separate high tension "earth" wire is not required, as the earth wire is connected inside the coil to the wire which goes to the contact breaker.

It is essential that the gap between the wires be of approximately the correct dimensions. For accumulator ignition the distance is $\frac{1}{50}$in., or slightly wider than the thickness of an ordinary visiting card. For magneto ignition it is preferable to have the points slightly closer.

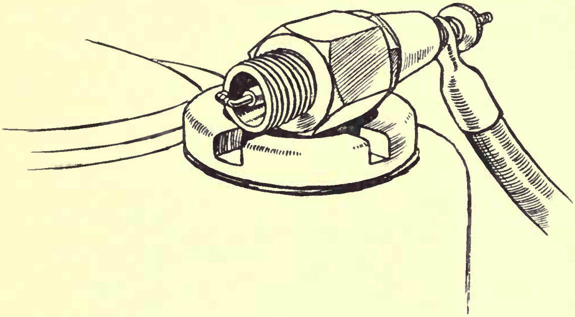

FIG. 15.—Testing a sparking plug.

Sparking plugs fail either on account of their insulation I. cracking, allowing the current to pass through the crack in preference to jumping the gap, or on account of short-circuiting taking place owing to the inner surfaces becoming coated with soot or moisture. Sometimes when an engine is started up on a cold morning these surfaces will become quite moist, and occasionally the gap will be bridged over with a drop of moisture. The central wire K should be quite tight and the sparking plug itself should be screwed firmly into the engine. Some times, chiefly with magneto ignition, the ends of the wires at the spark gap become corroded and require cleaning.

To test the complete ignition system, the sparking plug should be removed and laid on the cylinder, as shown in fig. 15. It will be noted from this figure that the plug is so rested that the metal body M (fig. 14) touches the cylinder, but the wire K does not. The current is therefore free to run down the wire and jump the gap at the ends of the wires, which would not be the case if the wire K or its terminal touched the cylinder.

With the sparking plug placed in this manner the engine should be turned round by hand, with the switch on, so as to allow the whole system to function ordinarily. It should be noted whether sparking takes place periodically at the sparking plug, a matter easy to ascertain in the dark. If the trembler buzzes and a spark does not occur, a change of sparking plug should be tried. If the change does not remedy matters, the high tension wiring should be examined to see that the insulation is in good order, otherwise the current will leak through the insulation rather than jump the spark gap. If, however, the trembler on the coil is not buzzing, it is obvious that the trouble is in the primary system. The accumulator should be tested and the various platinum contacts looked to as described previously. If the insulation is defective, and new wires cannot be fitted, the defective parts can be wrapped with insulating tape, a stock of which should form part of the tool kit of every car. It is very useful stuff for repairing water and other pipe leakages, and for a number of other purposes other than mere insulation.

It will have been gathered that the points which require periodic attention, and which call for examination in case of failure, are: (1) Platinum contacts, (2) sparking plugs, (3) loose terminals, (4) accumulators, and (5) broken or chafed wires. All the exposed parts of the system should be kept clean and dry.

The previous description has been limited to the system employed on a single-cylinder engine. When applied to a multi-cylinder engine, such as a four-cylinder car engine, the parts are merely multiplied. One accumulator is common to all four cylinders, and it supplies its current to a single contact breaker, such as shown in figs. 10 and 12, but four blades and screws are provided, and each of these four is connected to a separate coil. The sparking plug for each of the four cylinders is therefore coupled to one coil, and that coil is connected to the correct contact breaker blade or screw. It is obvious that if the coils are connected to the wrong blades or screws the different cylinders will fire in the wrong order. A four-cylinder engine fires in the order 1, 3, 4, 2, see fig. 16, counting from either end. It is best to mark the cylinders commencing from the radiator end, calling the first No. 1, the adjacent one No. 2, the next No. 3, and that nearest the dashboard No. 4. The coils connected to these should be correspondingly marked, and likewise the terminals or some other part of the contact breaker.

Assuming misfiring occurs, it is naturally not a difficult matter to trace the cause in a single-cylinder engine, but with a multi-cylinder engine the process is a more difficult one. It is best, therefore, to eliminate some of the cylinders and allow the engine to run on one or two only. The usual method of doing this when a trembler coil is employed is to press down the blades E (fig. 13) of the trembler, bringing the blocks G into contact with the core H. When the blade is so depressed the platinum contacts are held separated and the coil will not work, so ignition will not take place in the corresponding cylinder. By cutting out three of the cylinders the fourth is permitted to work alone, and it can soon be ascertained by trial and error which of the cylinders is not working properly, and its individual ignition system can be overhauled.

It may be found when running the cylinders separately in this manner that one runs faster than another. For an engine to be in good condition, all the cylinders, when run separately, should run at about the same speed. If one cylinder runs slower it shows a weakness due either to slight loss of compression in that cylinder or through some other fault. With a contact breaker as shown in fig. 10 an adjustment can be made by moving the screws B slightly closer to or further from the blades to vary the time of firing of any one cylinder. With the contact breaker shown in fig. 12 the trouble may be due to unequal wear of the blocks on the ends of the blades D. If the latter can be adjusted a little further along or a little shorter the time of the cylinders can be varied separately.

The Magneto System.

On modern cars it is becoming the custom to fit a magneto alone, or combined with a stand-by accumulator system, and in general this custom is found to be perfectly satisfactory. The magneto is now so perfect that it requires practically no attention to keep it in good order, and it gives practically no trouble. There are many different types of magneto, but they practically all operate on the same principle. There is a revolving member arranged in bearings at the bottom of the horseshoe or U-shaped magnets. The extreme end of this revolving member, termed the armature, carries a contact breaker, access to which can be had by removing the cover plate. This contact breaker, in principle, is very much the same as that illustrated in fig. 10. As will be seen from fig. 17, it comprises a rocker A carrying at B a platinum contact point, which normally rests against a similar platinum point on the end of an adjustable screw C. The other end of the rocker is provided with a fibre block D, which, as the rocker rotates with the armature, strikes against fixed surfaces which take the form of inclined blocks E. The contact breaker is mounted upon a baseplate F, fixed to the armature by a central screw G. The whole contact breaker can be removed by first removing the contact breaker cover, next withdrawing the metal ring which carries the blocks E, and finally by unscrewing the screw G. The baseplate F is a tight fit on the armature-shaft, and therefore will not drop off when the screw G is removed. It requires gently forcing from its place, and when removed

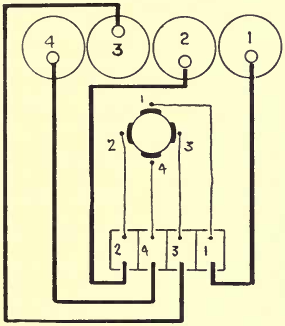

FIG. 16.—Order of firing in a four-cylinder engine.

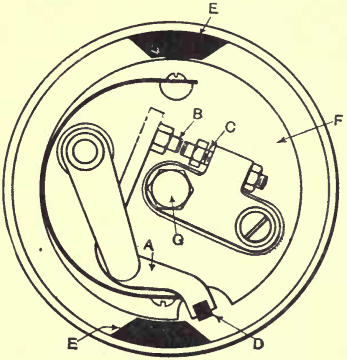

FIG. 17.—A magneto contact breaker.

it will be seen that it is fitted with a kind of key at the back, which fits into a recess in the armature, and ensures the contact breaker being correctly replaced.

The troubles to which the contact breaker is due are generally connected with the platinum points, which require cleaning and trimming, and a slight sticking of the rocker A on its pivot. Sometimes in damp weather the rocker will stick, and it is a matter of some difficulty to remove it and ease it on its pivot. In case of failure of the magneto, therefore, the contact breaker should be looked to to see if the rocker A is free. Touching it with the finger is the simplest way to find this out. Sometimes a bit of dirt may get between the platinum points, a somewhat difficult matter if the cover plate is always used. The platinum screw C requires correct adjustment. When the rocker is actuated by one of the blocks E, the gap between the platinum surfaces must be of certain fixed dimensions to obtain best results. These dimensions are notified in the makers' catalogues, and makers provide gauges to ensure correct setting of the points. Roughly, the gap should be $\frac{1}{2}$ mm., or $\frac{1}{50}$in.

At the forward end of the armature is arranged a carbon brush, which rubs on the armature. Occasionally this brush requires cleaning, and it has been known to break, so that periodic examination of it is advisable. From this brush the current is taken either direct to the sparking plug in the case of a single-cylinder engine, or to a distributer in the case of a multi-cylinder motor, which consists of a rotating arm A (fig. 17) and a number of contact segments 1, 2, 3, 4, over which the distributer arm rubs. Each of these segments is connected up to a different sparking plug, so that in the case of a four-cylinder engine there are four segments. It should be noted (see fig. 16) that a four-cylinder engine fires in the order 1, 3, 4, 2 from either end, that is to say, assuming the one next the radiator is fired first, the next one to fire will be the next but one away from it, that is to say, No. 3, reading from the front. The cylinder next the dashboard follows, this being No. 4, whilst cylinder No. 2 is the last. The wires to the sparking plugs must, therefore, be connected to the right distributer segments, which should therefore be numbered as shown in fig. 18.

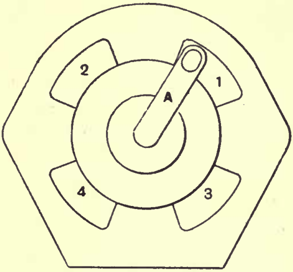

FIG. 18.

When the magneto has been removed it is a very easy matter to replace it incorrectly, in spite of considerable care being taken. The magneto is usually coupled to its driving-shaft through a simple form of coupling, and in replacing the magneto it should be noted that the coupling parts are reassembled in the same manner as before. Further, and this is where trouble is likely to occur, it must be noted that the distributer arm A (fig. 18) is in the same position as it was when the magneto was removed. The distributer arm is rotated at *half* the speed of the armature, so that, although the coupling between the armature-shaft and its driving gear may be in its correct position, the distributer arm can be in either of two opposite positions, only one of which is, of course, right, hence the necessity for noting the position of the distributer arm when the magneto is removed.

The magneto should be kept dry, and in washing the car, it sometimes happens that water drops on to the magneto. The switch sometimes causes trouble. In the magneto system the switch "earths" the current, causing the current generated by the rotation of the armature to go straight to the frame and the engine without passing through the wiring of the magneto, and to the sparking plugs. Hence if the wire drops off the switch and touches any metal part of the engine it will have the effect of switching off. Similarly, if the insulation chafes through trouble is almost certain to occur.

In the event of failure of the magneto, the simplest thing to examine first is the switch wire, and it is perhaps advisable to disconnect this altogether from the magneto, as sometimes a switch that appears in good order is slightly defective and gives a lot of trouble. If the switch wire and its connections are in good order the contact breaker should be examined as previously described. If this operates properly it should be seen that the distributer arm is on the right segment and that all the carbon brushes have been replaced. If a careful examination as described does not remedy matters the magneto should be sent back to the makers. Very often the magneto is blamed when it is operating perfectly, and the trouble is outside the magneto, that is to say, in the high tension wires or sparking plugs.

It should also be borne in mind that the magneto gives a very weak spark at low speeds, and practically none at all when the contact breaker is fully retarded, unless the number of revolutions per minute is high. Testing should therefore be done with the ignition advanced and at high speeds of rotation. The magnets retain their magnetism for a considerable period. Distances under 25,000 miles certainly do not seem to affect them, but a sudden blow will cause them to lose their virtue, so that when the magneto is removed care must be taken not to drop it. The simplest test of the magnets is to put a small piece of paper between the paltinum contacts on the contact breaker and then rotate the armature by hand. The resistance to rotation when the piece of paper is in place is very low, but unless there are two distinct drags or pulls for each revolution of the armature, remagnetisation is necessary, which is a job for the makers.

The correct operation of the magneto is dependent on absolutely correct timing, and to test the timing the distributer cover must be removed and the armature rotated until the distributer arm is on the correct segment. In the case of a single-cylinder engine there is no distributer to be troubled with. With the distributer arm correctly arranged the engine should then be moved until it is at a dead centre. The armature should then be rotated slightly until the contact points just break with the ignition fully retarded. This is a rough and ready setting, which will require slight delicate adjustment subsequently. It is a starting point, and subsequent adjustments can only be arrived at as the result of trial. Sometimes the coupling which connects the armature-shaft to the engine moves slightly, causing the timing to change, and bringing about poorness of running and a complete stoppage of the engine, the cause of which is difficult to locate.

Magneto makers supply full instructions for the adjustment and maintenance of their magnetos, and it should be the duty of every careful motorist to master thoroughly the simple instructions given.

With a good modern magneto very little goes wrong. The points which do occasionally require attention and which are most liable to give trouble, as will have been gathered, are :

1. The sparking plug.
2. The platinum points on the contact breaker requiring cleaning or truing.
3. Dirty carbon brush or strip segment.
4. Sticking contact breaker rocker.
5. Defective switch or switch wire.

There are one or two lubricators on the magneto which require filling every 1,000 miles or so, but oil should not be allowed to get on the platinum points or carbon brushes.

CHAPTER IV.

LUBRICATION.

WITH the very high temperatures, high engine speeds, and other conditions to which the engine is exposed, it will be understood that it is very important that efficient lubrication should be maintained. The usual method for lubricating a bearing is to provide an oil hole and a lubricator, allowing oil to pass through the hole to the bearing part. As an alternative, where the movement is small and the pressure relatively high, as in a spring shackle pin, grease is substituted for oil. In the case of an engine, it is obvious that individual oil holes or grease lubricators cannot be provided, and the usual method is to supply the oil to the necessary parts by means of a tube. In the simplest form this tube leads direct to the crank chamber, and through it a dose of oil is supplied periodically to the interior of the crank chamber. This system, termed the splash system, is used on motor bicycles and small cars, the oil being forced in by a hand pump. The usual dose is one pumpful for every five, ten, or fifteen miles, according to the type of engine, etc. The oil then enters the crank chamber and is churned up by the revolving parts, with the result that the interior is filled with an oily mist, which lubricates all the bearing parts, and also has access to the cylinder walls, so that the piston is correspondingly lubricated.

As it is an impossibility to produce an oil which will resist the maximum temperatures which occur momentarily during the firing stroke, the consequence is that a small amount of the lubricant is burnt, this amount varying with the tightness of fit of the piston and piston rings. The burning results in slight smoke from the exhaust, and if this smoking becomes excessive it will be understood that the excess of oil is passing the piston and entering the cylinder. This calls for the fitting of new piston rings unless the amount of oil being used is very excessive. The splash system is a very simple one, and there is nothing to go wrong with it. In cold weather it is somewhat harder to pump the oil into the engine, and, similarly, difficulty will be experienced in filling the oil pump. Many motorists use a thinner oil during the winter. Occasionally the oil pump will refuse to draw up oil and fill; this can be easily overcome by removing the top of the oil pump and pouring a little oil on top of the leather pump piston so as to seal it. Then the pump will work well.

With this system, and, in fact, with all engines, it is a very good tip occasionally to stop the engine when running downhill, as this allows the oil to settle and fill up certain oil cups that are fitted in the neighbourhood of the bearings, particularly on the connecting rod. These cups serve to collect oil and maintain a good supply at each bearing. The crank chamber occasionally requires a complete cleaning out, which is effected by draining off the old oil, washing out with paraffin, and then supplying a large charge of fresh oil. It is obvious that if the drain tap to the crank chamber, or the equivalent, is open, oil will leak out, and the system will fail, but apart from this and a broken pipe, lubrication by this means is perfectly satisfactory with small engines, particularly if inside flywheels are fitted, as on a motor bicycle.

An improvement on this system consists in allowing the oil to drip to the crank chamber instead of having to pump it in periodically. Obviously the drip lubrication must be started with the engine and stopped with the engine. If the first is overlooked bad running and eventual stopping of the engine will follow, and in this connection it is worth mentioning that if an engine pulls badly, temporary increase of lubrication is always worth trying, and frequently prevents a serious breakdown to the engine. If one forgets to turn off the oil tap the engine will be flooded with oil, and it will be found difficult to start, and when the engine is turned a gurgling noise will be heard. If the engine is started it will be found to smoke considerably, and it should immediately be stopped and the excess of oil drained off. On no account should it be left running in the hopes that the smoke will disappear, as the inside of the cylinder will become coated with oil, causing eventual stoppage, when the cylinders will have to be dismantled for complete cleaning, a lengthy and a dirty job.

In some cases the oil is supplied to the crank chamber by some means dependent on the engine's movement. Thus in some cases there is an oil pump operated by the engine which supplies oil continuously. Such a system requires no attention beyond individual adjustment in certain cases. There is no definite rule as to how many drops per minute should be given to any particular engine, as the dimensions and requirements are different with different makes. The manufacturers can usually give the desired information, but failing this it is well to set the lubricator so as to give just short of a continuous stream. If smoking follows, lubrication should be cut down. If the engine does not smoke, the adjustment might be increased till smoking is arrived at, then decreased to obtain a setting just short of that at which smoking occurs.

In other cases the oil is supplied by pressure from the exhaust. Some of the exhaust gases are allowed to pass by a pipe into the top of the oil tank, so as to force the oil up from the tank, so as to drip through a drip feed sight glass to the engine. Obviously when the engine is running very slowly with the throttle nearly closed there is very little pressure in the exhaust, consequently the oil may fail to drip on these occasions. To remedy this temporarily the end of the exhaust pipe might be closed, which will put up the pressure on the oil, causing it consequently to pour through the drip lubricator. If this is not the cause of the failure it will probably be found that the connections of the exhaust pressure pipe are loose, or that the pipe is choked up, which does occasionally occur, so that periodic attention to this is advisable.

Drip lubricator glasses are difficult to keep clean and transparent. If a fine wire or hair can be suspended from the drip nozzle the oil will drip down this and not adhere to the glass. Frequently the interior of the glasses becomes moist, owing to the oil tank being allowed to run empty when the exhaust gases pass through the tank into the drips. Naturally also the drip of oil is dependent on its thickness and its temperature.

The most approved system is the sump, fitted to modern engines. In this case the oil is kept in a tank either formed at the bottom of the engine crank chamber or separate, and the engine is provided with a pump, generally of the rotary type, which draws oil from the tank, pumping it through some form of indicator on the dashboard and so to the engine. It is usually supplied to the main crankshaft bearings, and the oil, of course, is under relatively high pressure, varying with different types of engines. The oil passes out of the bearings to which it is supplied and drips into a well, which might be the original sump or the tank from which it came. Thus the oil is circulated, being used time after time, and on each circulation passing through the bearings.

The remaining bearing parts are lubricated by the splashing of this oil and by the use of troughs, into which the connecting rods dip. From time to time the oil pump requires removal and cleaning, say once or twice a year, as sediment collects in it, and the same applies to any filter or filters which might be in the system. It is essential that the oil pipe connections be tight, and that there be a good supply of oil in the oil tank or sump, as there is a kind of tide which takes place owing to the fact that when an engine is running there is a considerable amount of oil in suspension and the level in the tank consequently low. When the engine stops the suspended oil naturally falls into the sump, and a false idea of the amount of oil in the engine may be created.

Where the oil tank is outside the engine it is very necessary to see that the connections at the ends of the suction pipe are sound. Personally, the author invariably wraps the ends of this pipe with insulating tape, as one or two breakages have been experienced, with the result that the pump, instead of sucking in oil, draws in a small amount of air, causing the lubricating indicator to work as usual, but resulting in insufficient lubrication. If the pipe for a distance of three inches or four inches at each end is well wrapped as described, it is impossible for any air to be drawn in, and the system will continue to work well, even if one of the connections is slightly loose or cracked. Incidentally a temporary repair of a connection or pipe can be effected with this insulating tape, which, as previously stated, should find a place in every toolkit. It is very essential with this system that all dirt and foreign matter be excluded. The oil must, however, pass through at least one filter before it is poured into the tank, and if a suitable and easily detachable filter can be arranged in the suction pipe leading to the pump, so much the better. It will be understood that filters require cleaning out periodically, say every 2,000 miles.

With a system in which the troughs are adjustable, being either coupled to the throttle valve or some other device so as to be automatically moved, it is very important that the adjustment be not altered, which is likely to occur accidentally when the connection between the trough adjuster and the throttle lever is disconnected.

For engines which are rather prone to preignite, castor oil is often used as a lubricant. This causes little or no carbon deposit, but it makes the valves and valve seatings very dirty. It also smells abominably.

The exterior of an engine, particularly a modern engine, ought to be clean, and it should not be imagined that its exterior conditions should be otherwise merely because its exterior is a cloud of oil. Should oil issue at the flywheel end it is an indication that the adjacent crankshaft bearing is not as good a fit as it should be. The remedy for it is rebushing, a job for the manufacturers or a really capable repairer, preferably the former.

Flake graphite is sometimes recommended as a lubricant, but it is dangerous stuff to use, as it is solid matter, and is liable to choke oil ways and do more harm than good.

CHAPTER V.

THE CARBURETTER.

UNDOUBTEDLY the engine depends largely for its power on the correct setting of the carburetter and the maintenance of correct adjustment. There are so many different types of carburetters at present employed that it is impossible to deal in detail with each, and it is only proposed to deal generally with carburetter action and to call attention to the defects to which carburetters are liable and set out their symptoms. If the construction of the particular carburetter employed is understood, the troubles which are likely to arise should be quite clear from the following description :

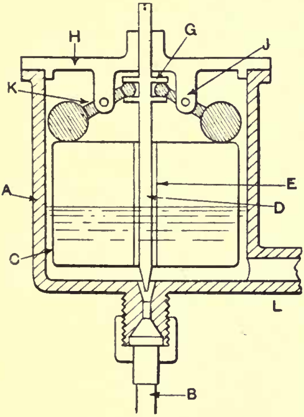

Fig. 19.
Float feed mechanism.

Fig. 19 is an illustration showing in its simplest form the float feed mechanism, a very simple form of mechanism, and one which is very often misunderstood. It comprises a cup or chamber A, to which petrol is admitted by means of the tube B. In the chamber A is a hollow metal float C, which is provided with a central passage E, through which passes a spindle D having a sharp pointed end, the spindle D being called the "needle valve." Towards its upper end the spindle has fixed to it a collar or reel G, somewhat resembling a cotton reel of small dimensions.

The lid H of the float chamber is either screwed to the main portion or otherwise fixed to it, and it is formed with two downwardly projecting brackets or lugs J, and to each of these is pivoted a short lever K, the inner ends of which lie in the groove of the reel G, whilst the outer weighted ends rest on the float C, when this is in the position illustrated.

When the float chamber A is empty of petrol, the float C naturally rests upon the bottom, and the outer weighted ends of the levers K drop, with the consequence that their inner ends rise, lifting the needle D and uncovering the inlet to the float chamber A. This is shown in fig. 19, the positions being somewhat exaggerated on purpose to make it quite clear that the needle valve is lifted. If now the petrol tap is turned on, petrol will enter past the needle valve and commence to fill the float chamber, in the course of which the float will rise, coming closer to the levers K. In time it will touch these, causing their inner ends to move down, pushing down the needle valve E and gradually reducing the inlet to the float chamber. The parts are so arranged and shaped that when the correct petrol level is reached the needle valve D has completely closed the inlet to the float chamber and no more petrol can enter, fig. 20. As the engine uses up the petrol in the jet, which is in communication with the float chamber by means of the passage L, naturally the level of petrol in the float chamber will fall, lowering the float. As the float falls

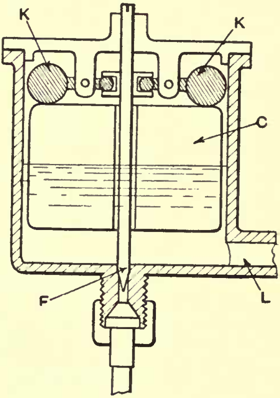

FIG. 20.—Float chamber.

it is followed by the levers K, which tend gradually to assume the position shown in fig. 19, with the result that more petrol is admitted to the float chamber, maintaining the level at the height indicated. This mechanism is, therefore, an automatic one for maintaining the level correct in the jet nozzle. It is a delicate mechanism, and requires examining from time to time, such examination entailing the removal of the lid H, with which will come away the levers and the needle valve. The float C should then be removed, exposing the bottom of the float chamber, in which grit and water are likely to collect. These should be removed with a piece of sponge or cotton wool to prevent any failure of the carburetter. If petrol dribbles from the carburetter when the car is standing, it is clear that the needle valve D fails completely to close the inlet to the float chamber. This failure may be due to a small piece of grit lodging in the seating of the valve or to the shape of the valve end F being incorrect. To remedy this the needle valve requires removal and a small quantity of crocus powder mixed with oil applied to the pointed end F. Fig. 20. The float chamber lid, with the needle valve, should then be put back and the needle spun lightly backward and forward to grind it in and make the surface of the needle and the seating exactly the same. This grinding-in process is the same as grinding-in the engine valves, except that the parts are more delicate. Consequently the grinding mixture must be finer and the pressure lighter, as very little grinding will be found necessary. Care must be taken to prevent the needle valve D being bent when removed, as it should work quite freely.

If leaking still continues, it may be due to the float having sprung a small leak, admitting a small quantity of petrol and rendering it heavier than it should be. To test if this is the case, the float should be removed and shaken close to the ear. If there is any petrol inside the float it should be immersed in hot or boiling water, which vaporises the petrol and causes it to pass out through the leak. This not only empties the float, but also indicates where the leak is, otherwise a difficult matter to locate, owing to its minuteness. If the leak is very small a temporary repair can be effected by smearing it with a very small quantity of soap, which does not dissolve in petrol. A permanent repair is to touch the leak with a soldering iron and then to scrape away as much solder as possible with a fine emery cloth, so as to prevent the balance of the float being upset by the addition of too much solder.

It is obvious that the carburetter must be fitted horizontally, otherwise flooding will occur, due to the jet being too low. If the carburetter is incorrectly fitted to the car this may occur.

There are many other cases of flooding. Engine vibration is one, but this generally occurs on single or twin engines. Again, the reel G (fig. 19), may be loose, and consequently have slipped down the needle, or it may be in the wrong position, to ascertain which the needle must be depressed with the finger, and if this prevents further flooding it is clear that the needle valve and its seat are in good order. Some floats require replacement, one side up only, but most modern ones are made reversible, so that it does not matter which way they are replaced. If the float should touch the lugs J it is clear that the reel G requires resetting on the needle, and flooding will continue until a clearance is provided. It is for this reason that the float is recessed or dished at the top. Similarly, if the reel should touch the lug J the same trouble will occur. Flooding is often due to the needle D being bent or, through some other reason, sticking in the float chamber cover.

If the petrol fails to enter the float chamber when turned on, indicated by the needle valve projecting its full height above the float chamber, see fig. 19, it is probably due to the petrol pipe or inlet passage B being choked. Sometimes the petrol tap itself is at fault, and, of course, for the petrol to pass out of the tank a small vent must be made in the tank filler to allow air to take the place of petrol. With tanks placed underneath the seat it sometimes happens that the cushion will rest on the vent or dirt will accumulate, preventing sufficient petrol passing to the carburetter.

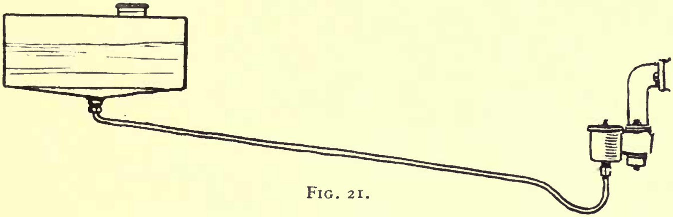

FIG. 21.

Sometimes a car will run all right for 200 or 300 yards, at the end of which the engine will stop. After a few minutes the engine will start up and run the car for the same distance. Obviously in this case the petrol is not reaching the carburetter fast enough, and during the few minutes the car has stopped the carburetter refills and the car runs properly for a few hundred yards, during which time the float chamber gradually empties. The cause may be in one of those just mentioned or may be due to an "air-lock" in the petrol pipe. The latter, if the petrol is gravity-fed, should drop on the way from the tank to the carburetter, and the angle of such drop should be greater than a slope of 1 in 5, see fig. 21, in order that when on a hill of this gradient the carburetter will not be so raised as to become higher than the petrol tank. In cases where the petrol tank is placed under the seat the carburetter has to be set very low to get sufficient fall of petrol to it from the petrol tank, and if the car fails on steep hills it is very possibly due to the petrol tank being insufficiently high. If a car should stick on a steep hill from this cause it can generally be driven up very easily on reverse, as the tank is then very much higher than the carburetter. If the tank is not quite full, filling up to the top may provide sufficient petrol to feed the carburetter.

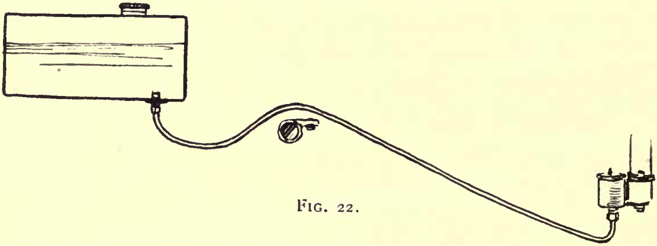

FIG. 22.

Referring to the "air-lock," as stated, the petrol pipe should fall steadily from the tank to the carburetter, as shown in fig. 21. Sometimes, however, the pipe is as shown in fig. 22, raised slightly at A so as to pass over a rod or some part of the car. In such a case, when the petrol is turned off, air will accumulate at the high point and a bubble will remain and partly block the pipe. Also if the pipe is provided with a coil, as shown in fig. 23, arranged in a vertical plane, a bubble will sometimes lodge at B, and grit and water at C, either of which will prevent or reduce the passage of petrol. Such coils should always be as shown in fig. 24, so that there is a steady fall through it.

A petrol filter is an excellent thing to have, but it requires periodic attention, and will, of course, choke up in time with an accumulation of water and grit. Once a month or so it should be cleaned out.

The simplest form of carburetter is provided with a single jet nozzle of relatively large bore of some predetermined size. Occasionally the jet nozzle will choke up, and to clean it no hard instrument, such as a needle, should be used, as this is liable to break off and permanently block the jet outlet. The obstruction can easily be removed by blowing through the jet. The presence of water in the carburetter causes very erratic running, and it is very hard to locate. It generally accumulates at the bottom of the float chamber and at the foot of the jet, and periodically all the passages should be cleaned. The best preventive is the placing in the petrol pipe of a really good filter and occasionally emptying this out.

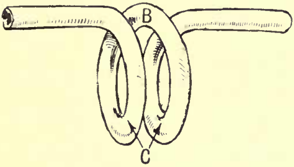

Fig. 23.—Incorrectly arranged coil.

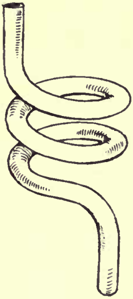

Fig. 24.
A correct petrol
pipe coil.

Reference should be made to the throttle valve, which, in its simplest form, is merely a tap which allows a large or small quantity of gas to pass to the engine, according to requirements. This gives little trouble. In cold, moist weather it is liable to jam through ice accumulating round it. The process of evaporation which takes place in the carburetter produces a very low temperature, with the result that the moisture in the air is turned to ice and is liable either to choke up the main carburetter passage or to coat the throttle. The remedy is to provide proper means for heating the carburetter, and if these means are provided, to see that they are working properly. Sometimes the air is drawn from a funnel around the exhaust pipe, and a gauze is fitted to the funnel to limit the amount of dust passing to the engine. These gauzes sometimes choke up, and in some cases, in the hot air pipe, is provided an opening covered with a slide, so that cold air can be used if required. Obviously in winter this hole must be closed. In some cases the carburetter is provided with a jacket, through which hot water is circulated. It must be seen that this hot water actually does go through the jacket, which can be ascertained by feeling the water pipes to and from the carburetter to test their temperature. In other cases hot exhaust gas is taken round the carburetter. As the exhaust gases are laden with oil the pipe to the exhaust jacket or the jacket itself often becomes choked.

In addition to the throttle some form of air valve is usually employed, this air valve being opened up as the speed increases and as the throttle is opened up. It is either controlled by hand or operates automatically. If controlled by hand the driver must realise that as he slows down, the air inlet must be shut down correspondingly, and *vice versa*. It therefore means an extra operation by the driver, but undoubtedly the best results can be obtained only by the use of a hand-controlled air inlet. To save the driver trouble, and to reduce as much as possible the demand for skill on his part, automatic valves are used, comprising merely a disc kept shut by a spring, the disc being sucked open as the engine speed increases. The tension of the spring requires careful adjustment, and the valve must be kept clean, otherwise it is liable to stick. In some cases the air valve is connected directly to the throttle valve, so that as the one is opened the other is correspondingly moved. In such cases the connection between the two valves must not be disturbed, as otherwise the relative adjustment is upset.

Carburetter troubles are due to too little or too much petrol. In the first case diagnosis is easy, as a banging or popping noise is heard in the carburetter or inlet pipe. In the second case there is excessive petrol consumption, a strong smell accompanying the exhaust gas, and a certain hesitation in picking up, somewhat as if the engine is choking for breath. Incidentally an extremely rich mixture causes boiling, burning of the valves, and choking of the silencer, apart from causing a very poisonous exhaust, which is liable to give a very serious headache, if not worse, if breathed.

In the event of the popping noise referred to occurring, it should be noted that the air valve, either hand controlled or automatic, is operating properly, and if of the latter type the adjustment should be slightly altered to confirm the diagnosis. The alteration to the adjustment should only be slight, as probably the trouble lies elsewhere. Apart from the possibility of there being a leak in the induction pipe, due to one of the nuts or attachments having worked loose, it is possible that the jet is either slightly choked or one or other of the petrol passages partially blocked. The carburetter should therefore be dismounted so as to expose the jet. The petrol should be turned on and the needle D raised, as in fig. 19. This allows free passage of petrol through the carburetter, and the petrol should spout out to a fair height above the jet and a steady stream issue. If the jet is choked very little petrol will issue. With modern carburetters it is very essential to see that all the connections of the induction pipe are absolutely tight, and in many cases makers smear the faces of the pipes with boiled oil before fitting them up.

Easy starting of the engine is largely dependent on efficient carburation. In cold weather petrol will not vaporise easily, and difficulty is always experienced in starting. This can be overcome by filling the water-circulating system with hot water and by heating the carburetter and induction pipe. For instance, hot water should be put into a rubber hot water bottle, which can be laid on the carburetter so as to warm it. The carburetter should be flooded slightly, a short time being allowed for this to vaporise. The engine should then be spun quickly, and if it does not start in the first few turns it should be left for a minute or two, in order that the petrol drawn into the engine may vaporise in the latter. Many people continue to wind away at an engine without realising that they are continuing to lower the temperature of the carburetter and induction pipe, still further reducing their chances of easy starting. The passage of the petrol along the induction pipe will cause it, in a short time, to vaporise, providing the temperature is not still further lowered.

If an engine fails to run slowly, apart from an error of adjustment in the ignition, it is generally due to the carburetter. For slow running a very small quantity of rich mixture is required, and consequently the air valve should not be opened at all. Similarly the jet outlet must be correspondingly small, which calls for some means of adjustment, and it is for this reason that the best forms of carburetters are provided with variable or multiple jets, so that as the throttle is opened up, either the size or the number of the jets exposed is increased. If the carburetter is of this type actual adjustment by a novice is somewhat difficult, and the makers should be consulted, as there are no hard and fast lines applicable to all types of carburetters which can be set out here.

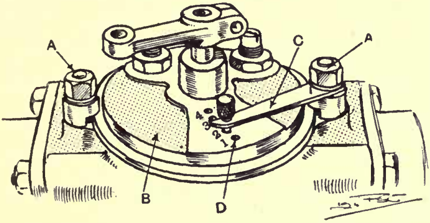

FIG. 25.—The White and Poppe carburetter.

In the White and Poppe carburetter, the top of which is shown in fig. 25, a simple form of adjustment is provided, which is effected by slacking off the two nuts A on each side of the carburetter chamber, rotating the body B of the carburetter slightly in the direction of throttle opening, and then resting the pointer C in the next hole at D marked on the centre of the carburetter body. To weaken the mixture the carburetter body is moved in the direction of closing of the throttle, and a very slight movement is necessary to effect a big difference in the result. In this carburetter the throttle comes up against a stop, which should be set so as to give the throttle just sufficient opening to keep the engine running slowly. This stop may require adjustment. If the engine does not accelerate or pick up quickly the makers should be consulted, and it may be mentioned that the makers of most types of carburetters have very fully illustrated handbooks dealing with the adjustment, etc., of their carburetters.

It is usual, in order to ensure a sufficient supply of petrol at starting, to flood the carburetter. This is effected by lifting the end of the spindle or needle valve D into the position shown in fig. 19. The petrol tap must, of course, be first turned on, allowing the carburetter to fill, when subsequent lifting of the needle valve will allow the excess of petrol to flow through the carburetter and flood it. It is best to raise the needle valve once or twice instead of holding it permanently up, and, of course, the amount of excess petrol required is very small in most cases. With a carburetter like the White and Poppe flooding must not be done, as the carburetter is set to give the right mixture without any flooding. If the carburetter is flooded it will not start unless the throttle is opened wide. With the White and Poppe or other single-lever carburetter the throttle must be set a very little bit open, but if the carburetter has been found to flood it should be opened wide till the engine has been running half a minute.

In the S.U. carburetter practically the only adjustment required, if good results are not obtained, is that of the needle which dips into the jet. If too rich a mixture is obtained the needle should be allowed to project slightly further from the piston and *vice versa*, or a needle of a different size obtained from the makers.

In the case of the Trier and Martin carburetter the makers issue full instructions as to sizes of jets advisable, and this and other instructions. It is, however, impossible in the present handbook to give full information respecting the complete adjustment of these and other carburetters on account of the space such information would occupy.

CHAPTER VI.

THE COOLING SYSTEM.

THE purpose of the cooling system is not to keep the engine as cool as possible, but to maintain it at the best working temperature. This temperature varies with different engines and according to the results required. If maximum power is required the temperature of the water is usually rather lower than when high fuel economy is the desideratum. In the first case the water is probably best at about 150° F. In the latter case the hotter the better, and it will be understood that if the temperature rises above 150° F. there will be a very slight loss in power, but probably an improvement in economy. The difference is so small that it really does not matter very much if the cooling water is kept close to boiling point. It is very easy in designing and constructing a car to make the cooling system sufficiently large to keep the engine quite cool, say at 100° F., but it is a mistake to suppose that such a low temperature is beneficial to the engine.

It should therefore be a matter of interest to a keen driver to obtain the temperature of his cooling water under certain conditions, as a test can easily be made by means of a thermometer, which can be bought for a shilling or two. This should be put into the top of the radiator immediately the car has stopped, and from it it can be learned whether the fan is really required or not. In winter there is no doubt fans are very rarely wanted, and cars run much better without them, but as summer approaches the need for the fan arises, which can be ascertained by the use of the thermometer as described.

If the water is found to be persistently too hot, and a reading of 200° F. is obtained frequently, probably it means that in practice the water is hotter than this, and very likely at or close to boiling point. In such a case steps must be taken to lower the temperature of the water, as otherwise evaporation will be excessive and serious trouble may occur through running the car with insufficient water, particularly if the cooling system does not include a pump, but relies on thermo-syphon or natural circulation. With a cooling system of this nature, see fig. 26, it is obvious that the water in the radiator must be above the connection of the water pipe B to the radiator, otherwise there can be no circulation, and the water in the cylinder jackets will merely boil, the radiator being, in such a case, of no utility. With pump circulation the water level *can* be lower than this, though this is not advisable.

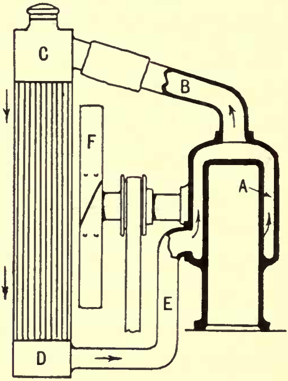

Fig. 26.—A simple diagram illustrating the thermo-syphon cooling system.

Fig. 26 shows the general arrangement of a water-cooling system in its simplest form, and is for this purpose shown applied to a single-cylinder engine. It will be seen that the water jacket A is connected by a pipe B to the top tank C of the radiator. This pipe B should rise slightly towards the radiator, and if no pump is fitted should enter the tank C as low as possible, leaving a large amount of water or " head " above the pipe B. The bottom tank D is connected by a rising pipe E to the water jacket, and if a pump is used it is located in the pipe E. The pump should always draw cold water from the bottom of the radiator and force it through the water jacket. The fan F is arranged as close to the radiator as possible to draw all its air through the radiator cooling tubes. With thermo-syphon cooling the water should not be allowed to fall lower than the top of the pipe B.

In the event of the water temperature being found to be too high, attention should be paid first to the carburetter to see that this is not supplying too rich a mixture, and the same applies to the other engine details, including the silencer, as this, when slightly choked, is very often responsible for excessive temperature of the engine as a whole, which, of course, is chiefly indicated by the greater heat of the cooling system.

The fan belt should be examined to see that it is driving the fan properly, and the spaces between the radiator tubes require occasional cleaning out. These become choked with mud, dead flies, etc., stopping the passage of air and reducing the cooling effect. Similarly the interior of the water pipes and radiator become coated with a furry deposit, owing to the presence of lime in the cooling water. For this reason it is preferable to use either rain water or distilled water in the radiator, when this deposit will not occur. If a deposit has occurred it should be removed, the process being not very difficult. For every gallon of water used a pound of soda should be added. The soda should be mixed with hot water, and when dissolved the mixture is poured into the radiator and the car run twenty miles or so and the solution run off. The circulation system should then be washed through with clean water. A substance called Seaose, sold by Brown Bros., is very effective, cheap, and easy to use. If grease should get into the cooling system, as by leakage from the pump gland, fig. 21, the water should be run off when hot, and next morning some petrol or paraffin put into the radiator and the engine turned round by hand to circulate it.

The various causes for the water running hot have already been stated, and these may be roughly summed up as follows:

(1.) Abnormal engine temperatures, owing to bad carburation, choked exhaust, etc.
(2.) Insufficient draught through the radiator and bonnet.
(3.) Silting up of the radiator tubes with lime deposit.
(4.) Choked air passages through the radiator.

These causes, it will be understood, apply chiefly to cases in which the cooling originally was perfectly satisfactory, but it sometimes happens that a new car cools insufficiently, and in addition to the above reasons it is possible that there may be insufficient space for the air to pass out at the back of the bonnet. It is obvious that for sufficient air to enter the radiator a corresponding space must be provided, adjacent to the flywheel or elsewhere, for the air to pass out, and if the undershield and dashboard prevent this it is clear that there will not be a free current of air through the cooling system.

Furthermore, the cooling effect is, to a great extent, dependent on the colour of the radiator tubes. A dull colour, such as dead black, is the best, and a bright or polished surface is the worst. If the car has been repainted, and the tubes painted either white or aluminium colour, a decrease in the cooling effect will be obtained.

In cars fitted with a pump in the circulating system it should, of course, be noted that this pump is working properly, and for this purpose the outlet from the pump should be disconnected and the engine run to see that the pump passes a good volume of water. With cooling systems in which the pipes are of small bore chokage is liable to occur, and if the above hints do not improve the cooling, each of the pipes should be tested in turn. Rubber connections are liable to kink and reduce the effective diameter of the pipe, and, of course, sharp bends either in rubber or metal pipes should be prevented.

The pumps on some old cars are friction driven—a bad practice, for which should be substituted a chain or gear drive. The modern thermo-syphon cooling system gives very little trouble. It depends for its efficiency on a good head of water, or height of radiator above the cylinders. In cars with dashboard cooling, such as the Renault and Deasy, the top of the radiator is considerably higher than the top of the engine, but in cases where the radiator is arranged at the front the water "head" is apt to be slightly less, and for this reason care should be taken that there is always plenty of water in the radiator, see fig. 26. With the large pipes used in this system leakage at the rubber connections is very liable to occur, and is somewhat difficult to prevent in some cases. Boiled oil applied between the rubber and metal pipes is sometimes used, and a really sound water pipe clip is an essential. Failing this, stout iron wire can be wrapped round and round and twisted up tight, but sometimes even this does not effect the desired result. A certain cure is to wrap the joint with elastic. A yard of catapult elastic should be obtained, of about $\frac{1}{8}$in. in diameter, and, if possible, of round section. This should be wrapped, under great tension, round the rubber connections and the ends tied together. The contracting effort of the elastic when under tension is considerable, and it will be understood that the grip acting under the great tension compresses the rubber sleeve, and it is impossible for the water to leak. The job can be finished off by covering the elastic with a strip or two of insulation tape, which hides it and makes a neat finish.

Many of the water joints are made with fibre washers. Before new ones are applied they should be soaked in cold water for about half a minute to soften them. Longer immersion causes them to swell, so that the holes come into the wrong position, but if allowed to dry they will shrink to the right shape. Where screws are used in the water jackets, and a tight joint is required, either boiled oil can be applied to the threads (which is not advisable, as it makes the screws almost impossible to be undone), or a washer of lead wire can be cut and slipped over the screw. When the screw is tightened up the lead wire will be spread and make a water-tight closure.

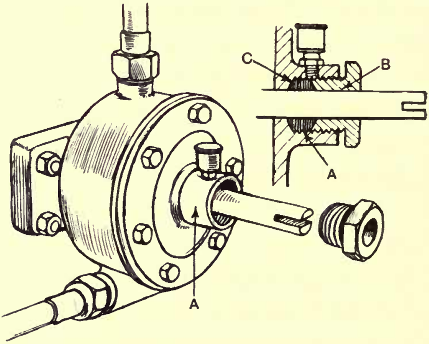

Fig. 27.—A water pump showing the gland.

In pump-cooling systems leakage sometimes takes place at the pump spindle, and this point requires careful lubrication with a heavy grease. At this point is arranged what is termed a stuffing box, see fig. 27, which comprises a body portion A and a gland portion B, which screws into the body A, leaving a space C, which contains packing bearing on the pump spindle. When leakage occurs the water passes out along the spindle, either on account of insufficient lubrication, as described, or because the packing C is too loose. To remedy this the gland B is screwed up further, jamming the packing at C tighter. In course of time the gland B is screwed up to the end and leakage still occurs, when the remedy in this case is to repack the stuffing box. To do this the gland B is screwed right out and the space C filled with a mixture of unravelled string and grease or any other lubricant, and the gland screwed up again. Many pump glands are kept adjusted tight by means of a spring.

It is obvious that the water in the cooling system must not be allowed to freeze, otherwise bursting of the cast-iron water jacket is very liable to occur. The radiator and pipes, being of sheet metal, are able to expand slightly, so that these very rarely crack, and the trouble is confined to the far more costly cylinder castings.

The simplest course is to drain the water circulation at the end of the day, taking care that the circulation is emptied, as some of the water inlet pipes to the bottom of the cylinders are not fitted at the bottom of the water jackets, so that unless special precautions are taken the mere opening of the radiator outlet tap will not drain the cylinder jackets to the last drop. In many cases water taps are fitted to the cylinders for this purpose, but in more modern cars the circulation drains itself automatically. With some kinds of water pump the water will not run through the pump unless the latter is running, and this has accounted for water being retained in the water jackets; the author has experienced a cracked jacket from this cause, when he thought that all the water had been drained off. The best method is to run the engine slowly whilst the water is being run off. Naturally the engine should not be run for long, but only just to make sure that the circulation is absolutely emptied. Some cars are fitted with water-jacketed carburetters, and it should be seen that the water is drained from these jackets at the same time as from the cylinder jacket. Otherwise, in the event of freezing, a slight leak is liable to occur which might escape attention and cause considerable trouble later.

Another alternative is to heat the garage, particularly at night time. If the car is merely to be left for a few hours, placing a rug or heavy coat over the radiator and bonnet will retain the heat for an astonishing length of time. For instance, one can drive a car a few miles out to a pond for skating and leave the car nearly the whole day without any fear of trouble if one or two coats or rugs are put over the radiator and bonnet as described.

Where a car has to be used at a moment's notice and under exposed conditions, as is the case with a doctor's car, it is best to use an anti-freezing solution, of which there are two in general use. The one is a calcium chloride solution, and the other is a mixture of glycerine. For the first, pure calcium chloride (it should be quite clear that this is not the stuff that is used in acetylene lamps) is dissolved in water in the proportions of 4 to 5 lbs. of chloride to a gallon of water. Such a solution will not freeze until a temperature very close to zero is reached. If the calcium chloride solution is not very pure it is liable to contain hydrochloric acid, which would naturally act on the metal. To remove the acid a handful or two of lime should be mixed with the solution, which should be poured through a fine filter before being used. Such a strong solution as this is liable, if the acid be not fully neutralised, to corrode the radiator, so it should not be used when it can be dispensed with.

The glycerine solution is merely a mixture of commercial glycerine and water. The purest glycerine is not necessary, and the proportions can be varied according to the temperature to which the car is likely to be exposed. For instance, four parts of water to one of glycerine freezes at $27\frac{1}{2}$° F. A 30% solution freezes at 25° F., and a 40% solution will not freeze till the zero point is reached. A 35% solution is therefore probably the most suitable. The glycerine in the solution will not evaporate, and any loss should be made up by water alone. If there is any leakage, naturally fresh solutions of the proper proportions should be added.

Glycerine if not very pure attacks rubber slightly. The best method of application is to make the solution with rain water and put it in the engine when the latter is hot, and then run the engine to mix the solution, and not to use it except when absolutely necessary.

It has often been suggested that a thin hydrocarbon oil, such as lubricating oil, should be used in place of water. Naturally this would not freeze, and if its specific heat is sufficiently high, that is to say, if its capacity for absorbing heat is sufficiently great, it would probably work admirably. Oil attacks rubber slightly, and the rubber connections would require renewal from time to time.

In the event of a cracked water jacket being experienced there are various methods of repairing it, according to the size and location of the crack. If a very small crack, it will gradually take up of its own accord, owing to the formation of rust, and this process of rusting can be assisted by removing the cylinder and filling the water jacket with sal ammoniac solution. The outlet from the jacket should be plugged and the jacket filled up to the height of the crack with a strong solution of sal ammoniac and left for a few hours and then washed out. As an alternative to sal ammoniac, copper sulphate may be used, the jacket being filled to the right level with a slightly concentrated solution. If the solution in this or the sal ammoniac process leaks out through the crack, the cylinder should be stood in a basin to catch the leaking liquid, which can then be poured back into the jacket. The crack will then gradually seal up. It is often, however, a matter of days if the crack is big. Another method is to fuse the two sides of the crack together with an oxy-acetylene flame. There are various firms who undertake this class of work, amongst whom may be mentioned Messrs. Thornton-Hoddle, Ltd., Victoria Street, Westminster, S.W., and Magnoid, Ltd., 2a, Camomile Street, London.

To prevent the crack spreading, a small hole should be drilled at each extreme end, which limits the stresses and prevents any increase. These small holes can, of course, each be plugged by means of a set screw.

Another process, where the crack is accessible, is to caulk it. In such a case the crack is limited by forming holes at each end, and is then opened up somewhat with a three-cornered chisel so as to form a dovetail groove along it. Solder can then be run into this and then caulked or hammered over.

A further method of repairing is to apply a patch. As before, holes should be drilled at each end of the crack, and a wet sheet of asbestos placed over it, and a sheet of metal screwed down upon this. This is a somewhat clumsy repair, but it has often been successful.

Honeycomb radiators, being of somewhat delicate construction, with a large number of joints, are liable sometimes to " weep " or leak very slightly. Such leaks, it is stated, can be filled up by putting a handful or two of bran in the water circulating system. This converts the water into a very thin paste, the solid constituent settling in the crack and sealing it up. The author has never tried this process, but gives it for what it is worth. If one tube of a honeycomb radiator leaks badly, a plug such as shown in fig. 28 can be used. This consists merely of a long, thin bolt A with a soft plug B at each end, the plugs being forced into the radiator tube as the bolt is tightened up.

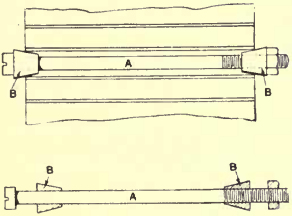

FIG. 28.—A plug for leaky honeycomb radiator.

In the event of the radiator being put completely out of commission, a temporary arrangement can be made if a length of hose pipe can be obtained. This should be connected to the outlet pipe at the top of the cylinder, and arranged in as exposed a position as possible, the other end being attached to the pump. As will be understood, the surface of the hose pipe is fairly large, and will enable the car to be run a few miles. It should be borne in mind that steam is likely to occur as the engine heats up, and will consequently blow one end of the hose pipe off the water pipe to which it is attached. One end of the hose pipe should, therefore, not be fixed to the water pipe, so that it can come adrift as described and act as a safety valve.

CHAPTER VII.

THE STEERING GEAR, BRAKES, AND TRANSMISSION.

AS the steering gear and brakes are the two items on which the safety of the occupants of the car chiefly depends, it should be the driver's duty from time to time to see that these are all in order. True they give very little trouble, and this is probably the reason why their overhaul is often overlooked, and why they occasionally fail.

Dealing first with the steering gear, from time to time the leather covers should be removed from the joints, and it should be ascertained that all the ball joints and securing devices, such as nuts, split pins, etc., are in order, and the leather covers should then be filled with grease and replaced. It is nothing short of criminal to replace any steering joint without ample locking devices, such as split pins. The same applies to the attachment of the steering gear itself to the frame.

In course of time an uncomfortable amount of shake or backlash occurs between the steering wheel and the front wheels, and such backlash is very difficult to prevent, on account of the large number of joints, or bearings, between the steering wheel and the road wheels. The only course is from the very start to pay careful attention to the lubrication of these joints and bearings. It is very hard to eliminate this backlash, and it occurs very easily, causing the car to become increasingly difficult to steer and tiring to drive. The only complete remedy is to fit new joints and new bearings to the steering wheels, or to the gear itself if the backlash is between the worm and worm wheel. In many steering gears some form of adjustment is frequently provided, the particular arrangement varying with cars of different makes. If no adjustment is provided it is possible to fit new bushes to the cross-shaft of the steering gear, these being slightly eccentric, so as to bring the worm a little bit further into mesh with the worm wheel on the steering pillar. If this is done, or if the means of adjustment provided are used, it may be found that the steering is somewhat tight when hard over on either lock, and allowance must be made for this to see that the steering is not likely to jam when turned far in either direction, which might cause a very serious accident.

The steering should be set up so that an equal steering lock is provided on both sides, that is to say, so that the car can steer to the same angle to right or left.

It is naturally very essential that the front wheels should be absolutely parallel with one another, and if undue wear of the front tyres occurs, the parallelism of the front wheels should be tested. In this connection it must be remembered that as the car runs along the tendency is for the fronts of the front wheels to separate, as shown by the arrows B in fig. 29, and if there is any shake or backlash such separation will occur slightly, so when testing the wheels for parallelism they should be pushed apart as far as possible at the front (as shown by the arrows B) to bring them into their normal running position. When a car is new the front wheels should be slightly closer at the front than at the rear, say about $\frac{1}{8}$in., so that as wear occurs they assume a parallel relative position.

To test the front wheels for parallelism the car should be run over a pit and the distances marked Y and Z in fig. 29 should be ascertained. The distance required is that from one rim to the other. It is no use measuring from the tyre, as this is often of irregular shape. The wheels at the front should be pushed apart as far as possible, as shown by the arrows B, after having first been brought into a straight steering position. The distance Y and Z can best be ascertained by using a piece of rod and cutting it the exact length of the distance Y. This rod can then be applied to the point Z, but it must be remembered *that the measurements must be made at exactly the same height from the ground in each case.* As the front wheels lean outwards, and are further apart at the top than at the bottom, it is obvious that if the measurement Y is taken close to the ground and Z very much higher up correct comparison is not obtained. Very often the measurement Y has to be taken low down, on account of the

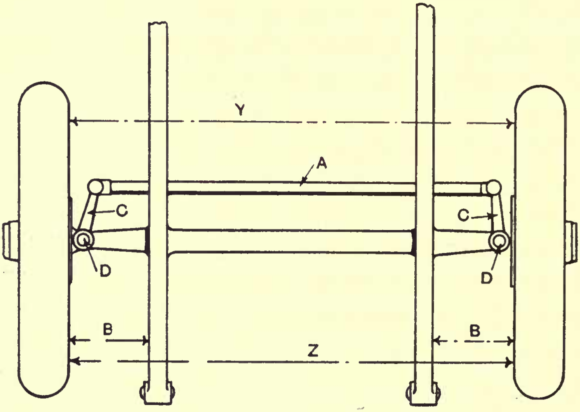

FIG. 29.

undershield, etc. As stated, the measurement Z with a new car should be very slightly less than Y, about $\frac{1}{8}$in. at most. If Z is larger than Y the steering should be corrected. If the front tyres are found to wear excessively on their outer edge it shows that the measurement Z is less than Y, and the reverse if wear takes place on the inner sides.

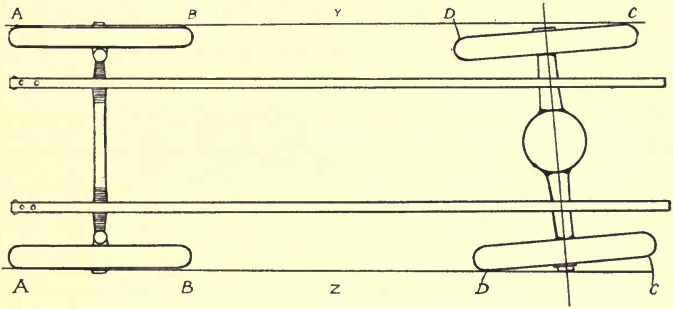

Fig. 30.—Testing the axles for the alignment of the wheels.

If the wheels are out of parallel, and no adjustment of the connecting rod A (fig. 29) is provided, either a new rod of correct dimensions can be made or one of the steering arms C can be bent. It should be put in a blacksmith's fire and rendered red hot and then slightly set to the proper shape to bring the wheels parallel—a ticklish job, as the amount of bend is small.

To test the alignment of the front or rear wheels, a cord is stretched from wheel to wheel, as shown in fig. 30. First of all the front wheels must be set exactly parallel, and the string arranged as shown at Y and Z. The string should touch the wheels at the points A, B, and C. With some cars it will be found to touch the back tyres at the points D on both sides as well. Usually this is not the case, for the following reason: The front wheels generally lean out slightly, the tops being further apart than the bottoms, so that the points A A, B B are slightly further away from one another than the points C C should be. Consequently there is very often a small gap at D, but this gap should be the same on both sides of the axle. Obviously if the car has been in collision it is well to test the back wheels for alignment by means of a rod, as described in fig. 29. In fig. 30 the back axle is purposely shown out of alignment. It is liable to attain such a position if the radius rods on a chain-driven car are incorrectly adjusted, or if the car is habitually run loaded more on one side than the other. This causes the springs to settle down on that side and push the corresponding end of the axle further back.

Sometimes a car will "yaw" from side to side of the road when being driven at relatively high speeds. This may be due either to the front and back axles not being quite parallel, or to backlash in the steering, or to stiffness of the latter, or to a combination of any two or all of these defects. It is a somewhat difficult fault to remedy, and fortunately it rarely occurs; when it does it is best to call in the services of a capable *driver* with his head screwed properly on his shoulders. It is of little use employing a *mechanic* for this purpose, as he has probably had little experience of driving. Second-hand cars are sometimes very uncomfortable to drive at high speeds, for the reason above mentioned.

The front wheels should sometimes be jacked up and tested for shake in the vertical steering pivots D (fig. 29). If these pivots are slightly loose it may be well to turn the pins round half a revolution so as to bring new bearing surfaces into position, which will have the effect of slightly reducing the shake and postponing for a short time the necessity for replacing the pivots or rebushing.

Brakes require little attention beyond ordinary adjustment. If a brake is fierce a *little* grease on the surface will remove this, which sometimes occurs if the brake surfaces have been allowed to rust. Oil should not be allowed to get on to the brake drums, and if it does do so it is either due to the lubricant in the back axle being used too thin or in excess, or to new felt washers being required in the axle. If this fault cannot easily be removed the makers should be consulted. Many drivers are apt to overlook their side brakes, which consequently are of little use in the event of an emergency. Hence it is good practice to use one's side brakes habitually, relying on the foot brake for an emergency or for town work, as this ensures the side brakes being kept in good working order, and also gets the driver into the use of this brake, the lever of which is sometimes not easy to find in a real emergency.

Most brakes are compensated, that is to say, when the brake lever or pèdal is actuated the two brakes are applied with equal power. In such cases only one adjustment is necessary to take up wear in both brakes. Other constructions necessitate two adjustments of the side brakes, roughly speaking, necessitating altering the length of a brake rod on each side. Now if one rod is made shorter than the other it is obvious that the corresponding brake will be applied harder, and but little power will be required to skid this wheel, whilst small braking effect will be obtained from the other brake. Hence the total effect of this pair of brakes is considerably reduced. It is consequently very important to see that the brakes are equally adjusted. This can be done roughly by jacking up one wheel, noting at which notch of the brake quadrant the wheel can just be turned by hand, or just not, as the case may be. The other wheel is then jacked up and the process repeated, adjusting the connections so that the same braking effect is obtained at both wheels for a given position of the lever. As an alternative, the car can be taken to a steep hill and allowed to descend very slowly, the brake being applied so as just to skid the wheels. It will then be found that one wheel will skid and the other run free, requiring the latter to be tightened up so that both wheels skid simultaneously. It may seem that this is a somewhat drastic process, but if it is done carefully, with no passengers in the car, the wear on the tyres will be infinitesimal, and far less than would occur normally by having the brakes unequally adjusted.

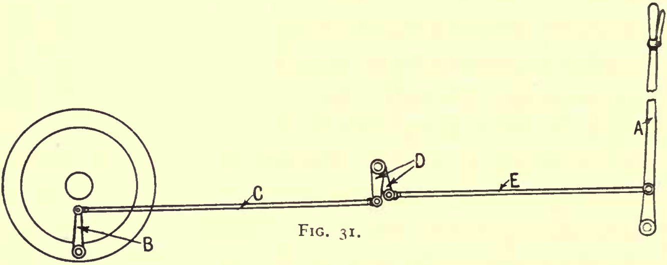

FIG. 31.

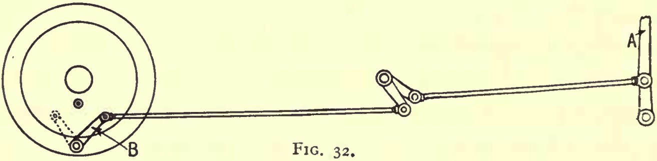

FIG. 32.

In course of time the braking effect may be found to be not so good as was originally the case when the car was new, and in some old or second-hand cars this is particularly noticeable. It is due to the brake-actuating levers not being in such an effective position as was the case before the brake surfaces and their actuating parts become worn. Figs. 31 and 32 explain this. These show the side brake lever A, which actuates the rear brake through a short lever B. This latter is connected by a link C to levers D, one of which is coupled by a rod E to the brake lever. For the brake to be most effective the levers B, D, and A should be at right angles to the rods C and E when the brakes are applied, as shown in fig. 31, and this is the position these parts usually take when the car is new. As the parts wear the rods C and E have to be shortened, drawing the levers B and D further from their perpendicular position, causing the braking effect to decrease gradually until a position is arrived at which is shown somewhat exaggerated in fig. 32, in which it is obvious that the pull of the brake lever A can exert but little power at the actual brake. The remedy is to reset the parts so as to bring the lever B into the position shown in dotted lines (fig. 32) when the brake is off, so that when the brake is applied it will come into the previous vertical position. This can be done in different ways, either by removing the lever B and bending it, or by making a new cam or expander inside the brakes, or by relining the brake drum, or by resurfacing the brake shoes. The Rolls-Royce car is provided with a particularly neat means of adjustment to cope with this.

In other types of brake the same effect gradually occurs, and it should be remembered that *the brake rods should be at right angles to the levers to which they are attached when the brake is applied*. This is the most effective position, the efficiency falling off as the angle gets further away from a right angle. If this relative position between the lever and rod is maintained the brakes will retain their original efficiency.

It is very desirable that the clutch should be kept in tip-top condition, otherwise it is liable to cause a good deal of trouble on the road, either on account of slipping or fierceness. The defects of the first are obvious, whilst in the second case the tyres are worn out very rapidly. The simplest treatment in the case of a slipping or a fierce clutch is to give it a dressing, but the correct dressing is not generally understood. If the clutch slips it is usual to apply a vegetable oil, such as castor or collan. If it is fierce, a little mineral oil, such as engine oil, should be used. In the latter case a few drops should be applied to the leather each morning, and it will be found that the fierceness will gradually pass off, but that the clutch will require occasional lubrication in this manner, say, once a week. If the clutch slips excessively, the clutch cone should be removed and the leather surface examined. If shiny, it should be scraped or roughened with a coarse file and soaked in castor or collan oil. In either case it is well to readjust the spring. If the clutch is fierce, obviously the clutch spring must be weakened, and *vice versa.*

Fig. 33 shows a sectional drawing of a leather friction clutch, the spring being shown at A. If the clutch slips excessively, the nut B should be screwed up—or to the left. If it is fierce the spring should be weakened by screwing the nut B to the right. Very often the clutch will slip too much when engaging, through no fault either of the leather or the clutch spring. If the clutch is to slide into engagement easily it is obvious that it must be free on its bearing. In the case illustrated in fig. 33 the clutch cone C slides on a bearing at D, and the lubrication of this bearing is frequently overlooked. In the drawing a grease lubricator is shown at E, but in many cases only an oil hole is provided, and in some cases not even that. If the lubrication of the bearing D is overlooked for long it is liable to seize, in which case the clutch will be permanently in. The lubrication of this bearing is, therefore, extremely important.

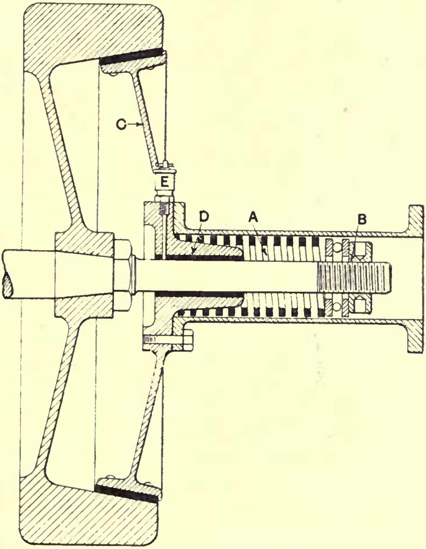

FIG. 33.—Sectional view of a clutch.

Other causes of slipping are shown in figs. 34 and 35. In fig. 34 the clutch leather is worn so badly that the clutch goes too far in and touches the front of the flywheel at A or the boss at B. The result is that the cone at C does not properly engage, and slipping occurs. The remedy is to releather the clutch, as explained later. In fig. 35, owing to the clutch leather having been too large, the male cone A does not engage far enough, with the result that a shoulder is worn on the leather at B, preventing the clutch cone A engaging properly. The remedy is obviously to remove the clutch cone, cut off the shoulder B, and scrape the leather until the cone A is free to go in far enough, as shown in fig. 33.

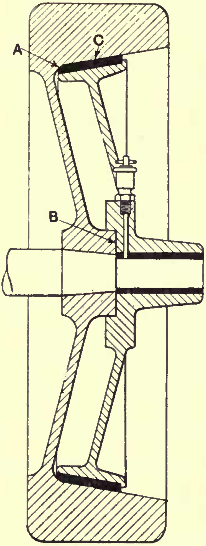

Fig. 34.—A common cause of clutch slipping.

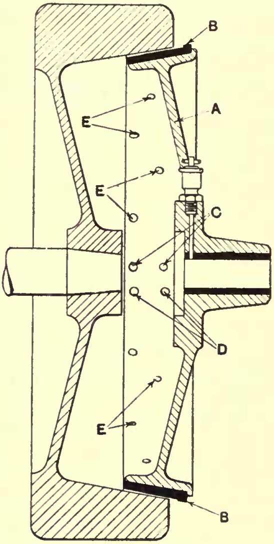

Fig. 35.—Another cause of clutch slip.

The process of releathering a clutch sounds very simple, but as an actual fact it is not very easy. A suitable strip of leather should be obtained, thicker than the old leather, but not too thick to allow the clutch to go right in, as shown in fig. 33. A paper template or the old leather should be used to mark off the correct shape of the new leather, and it will be seen that when set out flat the leather is curved in plan. The shiny surface of the leather should be applied underneath and the rough surface on top. It will be found that in the clutch cone there are usually four holes close together, as shown at C and D in fig. 35. One end of the leather strip should be secured to the clutch cone by rivets through the holes C, taking care that the rivet heads are sunk well below the surface of the leather. The leather strip should then be wrapped round the cone in its proper position till the other end reaches the other holes D. The leather should then be cut a shade short of the end already fixed, as it should be stretched in place when properly fitted. The leather is now pulled partly off the cone and the free end fixed to the pair of holes D. It will now be found that the leather strip requires forcing on the clutch cone, so that when ultimately fixed it will be stretched throughout its length. It can now be fixed by the remaining rivets E, the heads of which must lie below the leather surface. When the leather is in place the cone must be mounted in a lathe and the leather surface trued up so as to be absolutely circular. When finished it is dipped in castor oil and allowed to remain to soak a day or two.

Many clutches are provided with small springs, which lie under the leather, so as to cause it to stand up at those points. These are provided to ensure gradual engagement of the clutch cone and prevent fierceness. Sometimes these springs are simply flat pieces of steel, and at other times they take the form of wire springs, like the ones used on the valve stems. In these cases an adjustment is usually provided. If these springs are not strong enough they do not work, and the clutch may be fierce. If they are too strong they may prevent the clutch going right home under the action of the main spring A (fig. 33) and cause slipping. No amount of dressing or adjustment of the main clutch spring will then be of any use. It is generally known that this is the case if the clutch takes up very smoothly at first, but does not appear to go right home until after the car has travelled some distance. Again, the clutch will often slip when a rapid change of speed is being made with the engine running fast. In both these cases all that is necessary is to reduce the amount of tension, or the lift, of the supplementary springs arranged in the rim of the clutch cone C. It will be noticed in this case that the clutch does not slip when once it has gone home, and it is only in taking up that it fails. This makes it clear that the other causes of clutch slipping are not responsible.

The remainder of the transmission system gives little trouble, provided it is amply lubricated. For the gear box the lubricant should be sufficiently thin to find its own level and sufficiently thick so as not to leak out of the bearings. If considerable leakage takes place grease alone must be used in the gear box. A gear box which will not hold a fairly thin lubricant is to be condemned. Thick grease in a gear box will absorb as much as 3 or 4 h.p. at high speeds, and the same applies to the lubrication of the axle. If very thin lubricant is employed in the axle, either, there must be very little of it, otherwise it will work out at the axle ends and get on the brake drums and render the brakes inefficient. The universal joints either between the clutch and the gear box or behind the gear box require very careful lubrication. They are of far greater importance than is generally supposed, and should always be enclosed and work in lubricant. If this is not the case the joints should be removed and the bearing pins drilled and provided with lubricators, a job which any capable repairer will do quite easily. It must be remembered that the joint revolves rapidly, and the centrifugal action will do its best to throw out the oil, and probably also the lubricator. It is therefore best to use thick grease and a lubricator with a locking lid, of which many types are made by Rotherham and Sons, of Spon Street, Coventry.

Occasionally it happens that the third or fourth speed (whichever happens to be the direct gear) will not stay in position, but jumps out. This may occur when the car has been in service a considerable time, and is owing to the fact that the connection between the gear lever and the gear wheel or dog clutch has worn so much as not to push the dog clutch far enough into gear. The remedy is either to renew the worn parts or to file the gear quadrant so as to allow the lever to move further into the " in gear " position.

It often happens that difficulty will be experienced in engaging the first or reverse gear. These gears then wear out very quickly. This is owing to the clutch cone C (fig. 33) not stopping rotating when the gear is engaged. Before either of these gears is put into mesh the clutch pedal is depressed so as to bring the gear wheels to a standstill. Sometimes the clutch cone C will continue to revolve, and to prevent this a clutch stop is often fitted. In many cases the fault is due to the driver, who moves the speed lever simultaneously with the declutching, and this does not give the clutch time to stop spinning. It is very important, therefore, to hold the clutch out for some seconds before the gear lever is moved to engage either the first or the reverse with the car standing still.

It can easily be ascertained if this is the cause of the trouble if the footboard be raised, and the fact that the clutch cone is spinning or not can at once be seen.

The general procedure of changing speed cannot be described at length here, but it may be stated briefly that changing up, *i.e.*, from first to second, second to third, and third to fourth, should be effected with the clutch pressed right out and the speed lever moved slowly, the throttle being meanwhile closed. In changing down, that is to say, from the higher gears to the lower, the clutch pedal need only just be pressed lightly, the throttle being open, and the lever pulled fairly quickly from one gear position to the other.

Often difficulty is experienced in changing down through the gate on a gate quadrant. This is easily overcome by first declutching, moving the speed lever into the neutral, the throttle being left wide open all the time. The clutch is then let in again and immediately taken out, this being in order to run the gearshaft very fast, as is required. Directly the clutch is disengaged the second time the speed lever is pushed into the new position. The process is, therefore: Leave throttle open, declutch, push speed lever into neutral, let in clutch again and immediately declutch, and put speed lever into new position, then let in clutch quickly. It is very important to remember that when changing up into a higher gear the throttle must be closed as the clutch is taken out, and opened again when the clutch is fully engaged. The two operations should be made simultaneously. In changing down into a lower gear the throttle must be left open. In some cases changing down can be effected without taking out the clutch, but it must always be taken out fully when changing up.

CHAPTER VIII.

TYRES.

THERE is not the least doubt but that it pays anybody who is concerned with the looking after of a car to understand the construction and repair of his tyres thoroughly.

Tyre construction has improved considerably during the last few years, and actual road troubles on this account are very few and far between, and such troubles as do arise can be dealt with in a few minutes if detachable wheels or some form of spare wheel, such as "Stepney," is fitted. As stated above, an intelligent grasp of the construction of the tyre and the functions of its different parts is of very great importance. In actual fact, the tyre is not a complex article, but the security or holding down bolt presents a small amount of difficulty to the beginner, even if he is an adept at handling and repairing bicycle tyres.

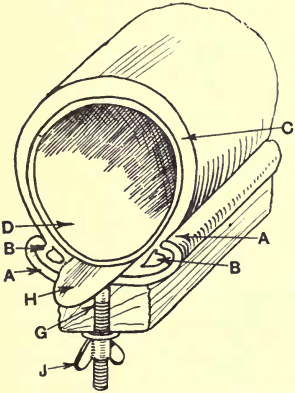

FIG. 36.—Section of tyre and rim.

To the uninitiated it may be stated that the tyre, fig. 36, consists of an inflated inner tube D and an outer protecting cover C. The former is constructed of rubber only, and is provided with an inflating valve, which is illustrated in fig. 40. This is slightly different from the type used on pedal bicycles, and will be fully described later. It is the air tube that provides the resilient support for the car on the road. If it were not of such delicate construction the outer cover would not be required. As it happens it is practically impossible to make an air tube of such stoutness as to withstand road wear and provide the necessary means of attachment to the rim. Therefore the outer cover is used in just the same way as a human being wears a boot on the foot to protect his more delicate sole from damage. Fig. 36 is a sectional view of part of a wheel cut in two to expose the interior of the tyre. As will be seen, the wheel rim is provided with two inturned edges A, which engage the beads B of the outer cover C. The inner tube D lies within the outer cover, as shown, and its removal or replacement can only be effected if one of the beads B is removed from under the edge A, as shown in fig. 37. To prevent the cover creeping round the rim when in use, the holding down or security bolts are employed. One of these is shown separately in fig. 38, and it consists of a stem G, with an enlarged head H of some soft and flexible material, the stem G being provided with a wing nut J. The stem G is of considerable length, and when in position, as shown in fig. 36, a good deal projects beyond the wing nut. In position the head H (fig. 36) is drawn down by the action of the wing nut J screwing on the stem G so as to grip the beads B and hold them securely in the bed of the rim and prevent any creeping of the cover in relation to the rim. These security bolts are only used on account of the great tendency there is for the cover to move around the rim, which, if permitted, would tear the valve from the inner tube.

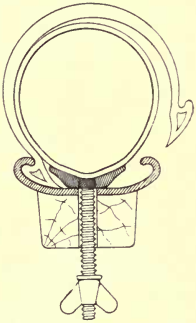

FIG. 37.—One edge of cover free from rim.

The construction of valve used is generally that shown in figs. 39 and 40. The first shows the parts all assembled, and the second the parts separated. First comes the large cap A, which is merely used to protect the other parts, particularly the screw threads, from the action of dust and rust. It performs no function in retaining the air in the valve, and the valve works perfectly well without it, but to enable the parts to screw into and out of place easily it is desirable to keep it always in position. Next comes the inner cap B, which screws down on the end of the valve tube C. If the interior of this cap B is examined it will be found to contain a rubber washer, which seats at D and actually seals the outlet to the valve. This cap is not really required for the proper action of the valve, but it acts as a safeguard, and if the valve is prone to leak at all it should be used, as it will prevent any air leaking out through the tube C. If the cap B is screwed down very tight the rubber washer, in course of time, becomes cut to pieces. In such a case a leather washer can be used.

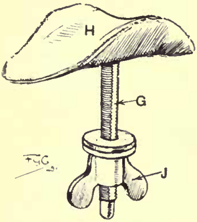

Fig. 38.—A security bolt.

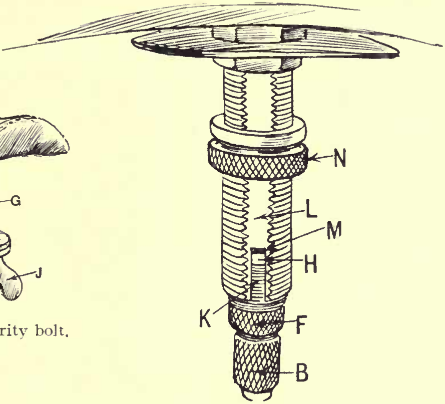

Fig. 39.—View of valve complete, except for outer cap.

To pump up the tyre the caps A and B are removed and the tyre pump connections screwed on to the tube C. Sometimes a small amount of air will escape during the operation of screwing or unscrewing the cap. This is due to movement of the needle valve E, and particularly does this occur with caps B of the type which have a central stem or needle fixed in them. This leakage will often occur directly the cap B is removed or replaced, but it does not indicate that the valve is faulty in any way. If the valve has not been examined for some time, removal of the cap B will perhaps move the needle valve E into the open position, and it will stick there, causing the air to leak out. If this happens—and its indication is a hissing sound, accompanied by deflation of the tyre—the trouble can be easily remedied by removal of the milled nut F which holds the tube C in place. This tube can now be removed, together with the needle valve E, which may be found to be stick-

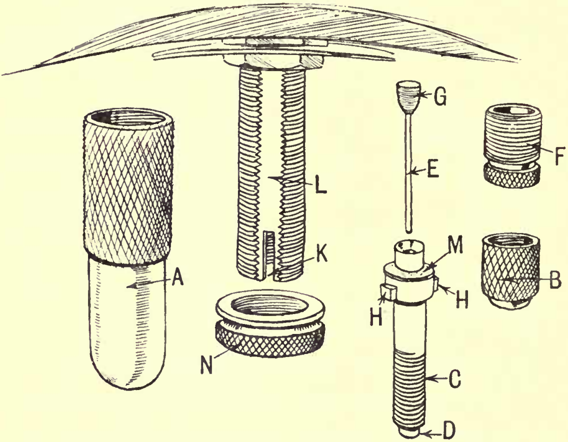

FIG. 40.—Valve parts separated.

ing in position, or there may be a small piece of grit lodged on the rubber head G, or this may have become dead, *i.e.*, too hard.

In any case, in the event of the tyre deflating when the cap B is removed, the needle valve E should be taken out as described and made perfectly free in the tube C, and the latter and the milled nut F replaced, taking care that the little square shoulders H go into the slots K in the valve body L. The tube may now be pumped up, and the valve should hold the air properly in between each stroke. If it does not, turn the wheel until the valve is uppermost, which, of course, encourages the valve E to fall into its proper place, which it may be assisted to do by slightly tapping the valve. To deflate the tube, slack off the nut F and pull the tube C downwards. The parts have the same reference letters in both figs. 39 and 40.

In the event of continued leakage through the valve, it should be ascertained whether the leakage takes place through the needle valve E or through the seating of the tube C. Around the lower end of the tube C is a rubber washer M, which seats inside the screwed body L and makes an airtight joint between the tube C and the body L. If this is to be effective the milled nut F must be screwed up fairly tight. If too tight, in time the rubber washer M will require renewal.

To ascertain at which point leakage occurs, the tyre should be inflated and the wheel turned until the valve is in its uppermost position, and a tumbler of water held up to the valve, as shown in fig. 41, the caps A and B having been removed. If the tumbler is so held that the nut F on the tube C alone projects into the water and bubbles take place, it is obvious that air leaks along the tube C, and consequently it is the valve E which is defective. If no bubbles occur at the point D, the tumbler should be held higher up until the end of the slots K is covered. If the washer M leaks the bubbles will come out of the slots K.

Sometimes the washer M will stick in position, and when the tube C is removed, a new one may be replaced without the defect having been removed. In the event of valve trouble, the seating for the washer M inside the tube L should be examined, the needle valve E looked to and straightened, and if the rubber head G is not clean or soft, the needle valve should be replaced. The Dunlop Tyre Co. issue a box of spare washers, needles, etc., containing all the parts necessary for the cost of a few pence.

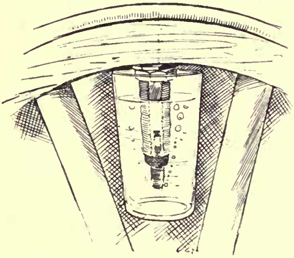

Fig. 41.—Testing the tyre valve with a glass of water.

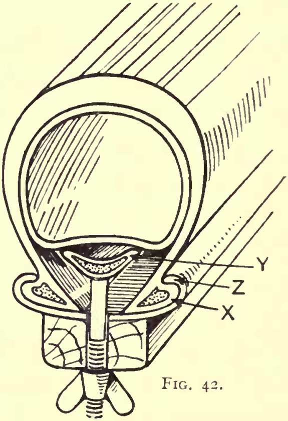

Fig. 42.

The valve body L projects through a hole in the wheel rim, and is held in position by a milled nut N, which screws upon it, and should be very tight, so as to maintain the valve in a true radial position with regard to the wheel.

A defective valve will often give a great deal of trouble, and a motorist frequently takes out his tube time after time hunting for supposed punctures, when all the time the trouble is due to the washer M or the needle valve being slightly defective, so that it is always as well to examine the relatively accessible valve before the tube is taken out.

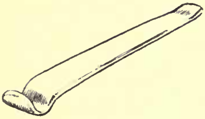

Fig. 43.—A tyre lever.

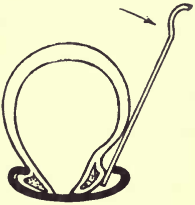

Fig. 44.

To remove the air tube all the loose parts illustrated in fig. 40 must be removed, leaving the valve body L naked as it were, and free to be pushed through the hole in the wheel rim. It should then be pushed into the tyre, and allowed to stay as far in it as it will. In some cases it may spring out the whole way, whilst in others it may stay half-way in. The farther in the better, but in any case it should be seen that the valve body is free in the hole. Next, the wing nuts J (figs. 36 and 38) on the security bolts must be unscrewed to the very end of the stem. They need not be removed. Having unscrewed these, the security bolts should be pushed as far into the tyre as possible, just as the valve has been. This is in order to bring the heads H away from the beads B, and leave them perfectly free. This position is illustrated in fig. 42. Either side of the outer cover can be removed by merely taking the bead X past the security bolts Y, and lifting it over the inturned edge Z of the rim. This sounds an easy operation, but it requires three strong levers for its carrying out. These, as shown in fig. 43, are provided with a plain end and a hooked one. For removing the tyre the plain end is used. First of all, the bead is pushed over as far towards the security bolt as possible, and the lever pushed down between the bead and the rim edge, as shown in fig. 44. By depressing the hooked end of the lever, and moving it through an angle, as shown by the dotted arrow, it will be clear that a position will be arrived at corresponding to that shown in fig. 45, in which the edge of the bead A is partly lifted over the side of the rim. This first lever must be held in the position shown in fig. 45, when a second lever should be placed about six inches away from the first, and this pressed down into the position shown in fig. 45. A third lever is then used in the same way on the opposite side of lever No. 1, as shown clearly in fig. 46. When the third lever is brought into position, it will be found that lever No. 1 is perfectly free, and will drop out. It should be removed, and used six inches or so from the other two levers, and these in turn will be freed. In this manner the cover is forced off six inches at a time, and when about half the circumference of the cover has been removed, it will be found that the other half can be pulled off by hand as a rule. It will be clear that the commencement of operations should not be at a point close to the valve or any security bolt, and that during the operation the security bolts should all be perfectly free.

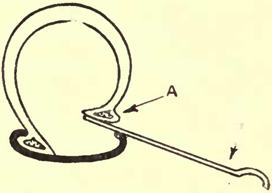

FIG. 45.

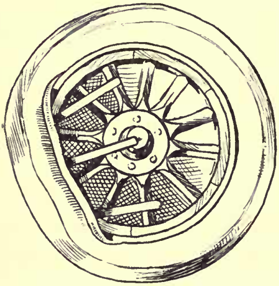

FIG. 46.—Showing three tyre levers in position.

As soon as the edge of the outer cover is completely removed, as shown in fig. 37, the air tube is free for removal. The valve body should, therefore, be pushed right through the rim into the inside of the tyre, and the whole of the tube can be withdrawn from inside the cover.

To remove the rest of the cover, the security bolts must be removed, and the lever is then thrust between the cover and the rim, as shown in fig. 47, the hooked end of the lever being placed, as shown in the drawing. By moving the lever upwards, the second bead of the cover is forced over the rim. Here again two or three levers may be required.

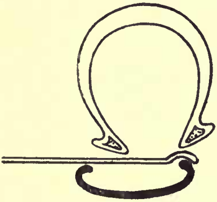

Fig. 47.

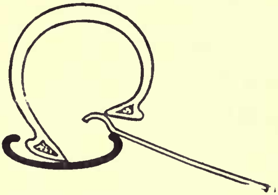

Fig. 48.

To fit a new cover, the operation is practically a reversal of that previously described, with the exception that the hooked end of the lever is used (fig. 48) the whole way through the process of fitting, whilst for removal the plain end is used, except as shown in fig. 47. When the first edge has been fitted in place, it has to be forced right over to the proper side of the rim before the security bolts can be put in place. This is sometimes a difficult matter, particularly when a new cover is used, as it is probably very stiff. To soften it the cover can be warmed, a simple remedy being to hang it over the radiator when the car is brought in from a run. Forcing over the first bead into its proper position can be assisted by hammering it with the end of the tyre lever, or by any other means which suggest themselves to the operator. As stated, when the first edge is in place, the security bolts are fitted, and as soon as they are *in situ*, the wing nuts J must be screwed on the stems a couple of turns. It will be found that the fitting of the security bolts is not an easy matter, especially with tyres of small sectional sizes. This operation is assisted by the use of a forked tyre lever, such as shown in fig. 49. Improved constructions of forked levers have been produced, notably one by the Dunlop Tyre Co. These considerably assist the fitting and removal of tyres; but, as their use is not so general as the simplest types of lever, their method of operation is not referred to specifically.

Having arranged the security bolts as described, the air tube is next put in place, and here is where the greatest care is required to prevent accidental nipping of the tube.

Fig. 50 shows the usual way in which a nip takes place, so that before the air tube is put into position, the security bolts must be all drawn down or forced towards the centre of the wheel as far as they will go, so as to preclude any possibility of part of the air tube being pinched under the head of the security bolt, as at A. If reasonable care is taken, a nip is very unlikely to occur. Some difficulty may be experienced in getting the valve into position, and here again the forked lever (fig. 49) is useful. Otherwise two levers may be used, one on each side of the valve opening. Some makers supply a dummy valve, which is fitted into place to facilitate placing the air tube in position. To prevent any possibility of a nip, the best practice is to deflate the air tube before fitting, and by complete deflation is not meant merely a removal of the valve parts, but the actual exhaustion of the air in the tube. The tube should be laid on the floor, and rolled up so as to squeeze out all the air through the valve. The dummy valve should then be put in place, or the valve with the parts C, E, and F, shown in fig. 40, so as to prevent any air entering the air tube. The tube will now be perfectly flat, and any possibility of it getting into the position shown in figs. 50 and 51 is prevented, as it will lie flat against the cover.

As the cover moves in relation to the air tube all the time the car is running, heat is generated, and there is a tendency for the parts to chafe. For this reason a lubricant is inserted between the tyre and the cover, taking the form of powdered French chalk, and it is very important that this should be used. Spare tubes should always be kept in a bag or box containing this chalk, and before a tube is put in place, a small handful should be spread out inside the cover.

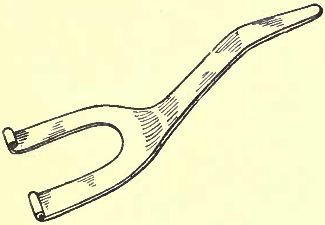

FIG. 49.

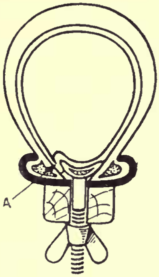

FIG. 50.

The second edge of the cover is replaced in position by a reversal of the process illustrated in figs. 44 and 45, with the exception that the hooked end of the lever is caused to engage the edge of the rim and the lever raised, as shown in fig. 48. It will be understood that the edge of the bead has to be fitted under the head of the security bolts, so that before the levers are used, the wing nuts J must be screwed as far towards the end of the stems G (fig. 38) as possible, and the security bolts pushed up into the tyre. Consequently, when the bead is forced over the rim edge, it will lie under the head of the security bolts, which should be screwed down after the whole of the bead is in place.

Fig. 51 shows another method of tyre replacement whereby damage occurs. If the tube is nipped in this manner close to a security bolt, the tyre will be cut through, and a serious burst occur, which can be obviated by the use of care during the fitting of the tyre.

Having fitted the cover in position and screwed up the wing nuts, the tyre can be inflated; but before this is done the milled nut N (fig. 40) should be screwed up tight, and during the process of inflating, this and the wing nuts should be screwed up.

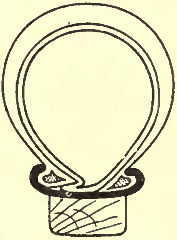
FIG. 51.

As is well known, the chief trouble to which tyres are liable is due to punctures, and these can very largely be avoided if periodic examination of the tyres is made. By this is not meant removal of the covers, but merely running the hands round the tyres to feel if there are any nails sticking in. The author makes a practice of this every hundred miles or so, and it is astonishing what a number of puncturing articles are removed before any harm occurs, and how few actual punctures are experienced. With tyres of the stoutness used on cars, the actual process of puncture is generally a lengthy one. The puncturing article is picked up and carried round by the wheel perhaps for a hundred miles, each impact with the road tending to drive it further in. If, therefore, a periodic examination is made, the nail, or whatever it is, can be removed before it has found its way into the tube. Further, if a piece of metal is left in the tyre, it will, in addition to the puncture, wear a large hole in the cover, allowing access of water to the canvas used in the tyre's construction, causing this to rot, become weak, and finally burst. If is therefore very important to examine the tyres frequently, and I am very emphatic on this point, as I have very little tyre trouble myself, which I attribute to this inspection.

In the event of puncture, the process of repair varies. In an extreme case, the tube may be taken out, a new one fitted, and the punctured one sent to the makers for repair, this generally taking the form of vulcanisation. In such a case the tube does not return to the owner for some days, whilst the repair is a relatively expensive one. In actual fact, such a repair is only necessary where the hole is a very large one, or is close to the valve or the joint, or where the puncturing article has made a number of holes.

The next method is to remove the whole of the tube, and either repair it then or at leisure, fitting a new one meanwhile. The simplest way in which the repair can be carried out, when the exact location of the puncture is known, is to pull out that part of the tube, patch it, and put it back again without having to remove the whole of one side of the cover. For instance, if a nail is picked up and the tyre goes flat in consequence, the wheel should be jacked up and turned round till the nail is found and brought to an easily accessible position. The position of the nail should be marked on the cover, and the nail pulled out, and either kept as a memento or thrown as far from the road as possible. The adjacent security bolts should be slacked off, and the tyre levers put to work at that part of the tyre where the puncture has occurred. One-third of the cover should be removed, and a corresponding amount of tube withdrawn, exposing the punctured part. If there is only one hole, the repair can be easily and rapidly effected; but if the nail has made a number of punctures, or if it has gone through both sides of the tube, it is very often safest to remove the rest of the side of the cover, take out the tube, and fit a new one, making a very careful repair at any suitable time. Full instructions for the patching of the tube will be found on the repair outfit. Briefly, the process consists in cleaning the surface of the tube over a small area of which the puncture is the centre. For an average nail hole this area should be about 1½in. in diameter. The cleaning is effected with a piece of sandpaper or a hard wire brush. A patch of suitable size should then be found and the proper side smeared with solution. The solution should be applied *as thin as possible and spread out evenly*, and a corresponding coating should be applied to the tube. In the course of a minute or so, if the solution has been applied thin enough, the coating should have dried. In any case it must be left to dry, when another coating can be applied, and so on. The more coatings, and the thinner each each is applied, the stronger will be the repair. When three or four coats have been put on, and each has become dry, the patch should be put in place centrally, and held firmly for a few seconds until the patch adheres all over to the tube.

Such a repair will not in the usual way stand very much heat or very hard work, and it is for this reason that vulcanisation of the parts is often effected. Personally, I always use "Patchquick" patches and repair solution. These are produced by Messrs. Woodgate and Sons, of Tiverton, and are very widely used. If a patch is properly applied with this process, it will never come off.

This system of patching is practically the only means of repair that can be carried out on the road, and it can be applied to quite large holes and even small bursts ; the larger are, however, better dealt with by vulcanisation. For this purpose it is better to send the tube to the makers. There are a number of very ingenious portable vulcanisers which can be carried on the car and used for tubes and cover repairs ; but, as the process takes about half an hour, it is not of general utility for road use. For cover repairs it is really only practicable to apply a canvas patch to the interior of the cover, and when this is done, or a patch applied to the air tube, care should be taken to dry up the repair completely when the patches are in place by the use of French chalk, otherwise the tube will stick to the cover. The method of applying a canvas patch to the cover is exactly the same as patching a tube. It is best to round off the corners of the canvas patch, and to apply a few more coats of solution than one would for an ordinary tube repair.

Burst covers can be temporarily repaired by the use of a tyre gaiter, of which there are many types on the market. The majority are easy to place in position, but in fitting it must be remembered that there is a slight tendency for the gaiter to creep in relation to the tyre, so it must be arranged slightly out of centre to the burst, so that when it creeps it will move into its proper position.

A good method of using up old covers is to fit one outside the other, which is a particularly good tip for winter use. One method is to cut off the beads, and, when both covers are removed, force the one inside the beadless cover, and then fit the compound cover in the same manner as a single one. Another method is to slit the beads radially, and then to force the cover so treated over the one on the wheel, and hook the slit beads together. Messrs. Frank Little and Co., of Newcastle-on-Tyne, make a speciality of dealing with old covers, their process being to remove the bead and stitch the two covers together. The author's experience of this process is very satisfactory. Another method of using up old covers is to obtain a strengthening lining, which is fitted between the cover and the tube. Again, special forms of strengthened air tubes have been produced, these containing a layer of canvas, which prevents the tube bursting.

As will have been gathered from previous remarks, a burst is due primarily to a cut in the outer tread of the cover, which allows the passage of water through to the canvas, which forms the strengthening part of the cover. Rotting takes place, and the cover becomes weak at this point, and bursts when its strength is not up to the strain it has to bear. To prevent this action taking place, obviously the thing to do is to close up the cut. This can really only be properly effected by vulcanisation, and it is for this purpose that small vulcanisers, such as the Harvey Frost, are of chief value. Other methods are to fill up the cut with tyre filling compounds, which are on the market, none of which are of permanent utility. Michelin Mastic is probably about the best. The operation is a somewhat tedious one, but if it is properly carried out, no doubt water is excluded.

Sometimes, fortunately very rarely, a tyre will crack along the side next to the rim. This is due to the edges of the bead chafing the underside of the rim, and is consequent on the tyre being of the wrong size for the rim, or to there being insufficient French chalk, or to the tyre being constantly run very much too soft for its load.

Now we come to a point of serious contention. Makers state clearly in their catalogues the pressure at which their tyres should be run, and the pressure within the tyre can be tested by means of the gauges sold for that purpose. Incidentally the gauges on the tyre pumps are of little or no value. Anybody who has persistently run his tyres at well under the pressures called for by the makers has probably obtained far better results both in the way of comfort and durability. This is the author's personal experience, and he has never come across anybody yet who had any objection to low tyre pressures. He knows of one very important motor car hire firm in London whose tyre bill was considerably reduced when those in charge insisted on the tyres being run at low pressures. The author runs his tyres at a full 20 to 30 lbs. below the maker's requirements, and gets extremely good results. If the tyre is pumped up harder it is obviously under greater stress and will burst more easily. True there are corresponding theoretical objections to low pressures, but the author recommends them, certainly with Dunlop tyres, with which most of his experience has been. With very low pressures, and, in fact, with all tyres, it is very important to keep the wing nuts on the security bolts screwed up tight, and also the valve nuts. It is also important that the bed of the rim be free from rust. Therefore when a tyre is removed the opportunity should be taken to give the bed of the rim a coat of black enamel.

Sometimes a tyre will develop a boil or swelling, particularly when a worn cover has been retreaded. Nothing can be done to remedy this, which is due to an accumulation of rubber material underneath one of the layers of tread. It does not necessarily denote an imminent burst.

As will have been gathered from the remarks on the steering gear, it is extremely important, to obtain good tyre results, to have the front wheels perfectly parallel with one another, the back wheels likewise, and the two axles parallel. There are, therefore, three points which require examination if bad tyre results are obtained, and it should be quite clear that each of these three points is looked to, as very often the alignment of the axles alone or the parallelism of the wheels is seen to. Further, the driving wheels must be kept in contact with the road. If the car is a light one, or if the weight on the back wheels is low and the car fast, it will not "hold the road," with the consequence that the back wheels will bound into the air, spin, and then come down on the road with a chafing action. Relative movement of the tyre to the road must not be allowed, either due to this or to fierce clutch or fierce brakes. If the back wheels do leave the ground at speed on a bumpy road, more weight should be arranged at the back, or shock absorbers or improved springing arranged. Makers seem to pay little attention to the weight concentration or springing of two-seated cars, on which it is very important to keep all the weight as far back as possible, and to fit good shock absorbers or auxiliary springs.

In conclusion, if bad tyre results are obtained, do not first blame the tyre makers, but rather look for faults in your car or yourself. Test the parallelism of the wheels and axles, see that the wheels do not leave the ground at speed, do not let in the clutch or apply the brakes fiercely, examine the tyres as often as possible for puncturing articles, and do not run your tyres pumped up too hard.

CHAPTER IX.

DIAGNOSIS.

Engine Fails to Start.

THIS is often due to the fault of the driver in omitting to

(1.) Switch on the current.
(2.) Turn on the petrol.
(3.) Advance the ignition (if magneto is fitted).
(4.) Retard the ignition (if accumulator ignition is used).
(5.) Shut the auxiliary air inlet (if provided).
(6.) Open the throttle.

It may be due to the engine not being rotated fast enough, especially if a magneto is used, or

(7.) To there being no lubricating oil in the cylinders.
(8.) To the carburetter being too much flooded, or to too much petrol having been injected.
(9.) If a single-lever carburetter is fitted, to the throttle being too far open.
(10.) Accumulators not being in place, coupled up, or sufficiently charged.
(11.) Petrol not reaching the carburetter.
(12.) Jet being choked.
(13.) Failure of contact breaker.
(14.) To contact breaker rocker of the magneto sticking.
(15.) Water on magneto or sparking plugs, either inside or out.

(16.) To insufficient heat to produce evaporation of the petrol in cold weather.
(17.) Condensation of the petrol in the inlet pipe in cold weather.
(18.) Loose terminal or wire.
(19.) Defective magneto switch or wire.

The best of drivers has often omitted to turn the petrol on or to switch on the current, and it is for this reason that the general routine is mentioned in addition to the more rare causes of starting troubles. The best procedure to ensure a good start is to race the engine slightly before switching off, and in any case to stop the engine on the switch and not by closing the throttle. See that the induction pipes do not leak at the joints, and if the carburetter requires flooding to start, get a Bowden tickler to render this easily effected without having to raise the bonnet. Most modern carburetters do not require flooding. With magneto ignition it is necessary to rotate the engine at a fairly high speed, and the ignition must be advanced as the maximum spark is obtained with the contact breaker in this position.

Engine Fails to Run Slowly.

This may be due to

(1.) Partially choked jet or fuel supply.
(2.) Air leaks in the induction pipe.
(3.) The mixture being too weak.
(4.) Automatic air valve spring too weak.
(5.) Carburetter throttle stop not adjusted correctly.
(6.) Magneto out of order and not supplying current at low speeds.
(7.) Carburetter insufficiently heated.

In course of time the magneto magnets deteriorate, and as the spark produced by a magneto decreases as the speed falls, it is obvious that a time is reached when the magneto fails to fire at low engine speeds. Generally the trouble is due to carburation, in consequence of the mixture being too weak, when the engine is running slowly.

Engine Fails to Run Fast.

This is generally due to

(1.) Mixture being too rich.
(2.) Automatic air intake not opening sufficiently.
(3.) Flooded carburetter.
(4.) Choked exhaust.
(5.) Insufficient valve lift.
(6.) Ignition insufficiently advanced.
(7.) Valve springs too weak.
(8.) Carburetter gauzes choked.
(9.) Insufficient supply of petrol to carburetter.

In this case the cause of the trouble is generally the reverse of that last mentioned. It is generally consequent on the mixture being too rich, or to the magneto or other ignition being insufficiently advanced. The limit of engine speed is determined by

(1.) The rapidity with which the cylinders can be filled with gas and exhausted, which is dependent on the size of the inlet and exhaust pipes, and the carburetter.
(2.) The rapidity of firing, which is dependent on the ignition advance.
(3.) The weight of the reciprocating parts. For very high engine speeds the pistons are specially lightened. But it is not advisable to run an

engine above 2,000 revolutions per minute if a cast-iron flywheel is used, as it is liable to burst under the centrifugal stresses assisted by the outward pressure of the clutch cone.

Misfiring.

This is generally due to the ignition, and may be traced to

(1.) Defective sparking plug.
(2.) Defective wire either in the primary or secondary circuits.
(3.) Pitted platinum contacts.
(4.) Platinum points not breaking sufficiently on the magneto.
(5.) Broken or dirty carbon brush on magneto.
(6.) Oil on magneto contacts.
(7.) Sticking of magneto contact breaker rocker.
(8.) Batteries discharged.
(9.) Loose terminal.
(10.) Water in carburetter.
(11.) Insufficient petrol reaching carburetter.
(12.) Insufficient lubrication.
(13.) Loss of pressure when petrol is pressure fed.
(14.) Water pump not working.
(15.) Magneto or switch wire defective.
(16.) Incorrect mixture.

If the misfiring is accompanied by banging in the silencer, it is generally due to the ignition, which fails at times to fire, and thus allows a charge of unburnt gas to pass to the silencer and there be exploded by the next properly fired charge. If the popping noise is in the inlet pipe or the carburetter, it is due either to the mixture being too weak, or to the inlet valve sticking open, or to an excess of carbon deposit. If the misfiring is not accompanied by any such noise, it is generally due to the mixture being too rich. In the case of a multi-cylinder engine it should be ascertained at once whether the misfiring is one cylinder or more, as described on page 45. Or the sparking plugs in turn can be short circuited, as by holding the metal part of a screwdriver against the terminal and the metal cylinder, taking care to hold the wooden insulated handle. With two screwdrivers against two plugs the engine can be caused to run on only two cylinders at a time, and in this manner the defective cylinder can be traced. If misfiring occurs in all the cylinders, it is obviously due to some accessory which is common to the whole engine, such as the magneto, carburetter, or accumulators.

Engine Stops Suddenly.

(1.) In most cases this is due to a broken wire or to the switch having jolted into the "off" position.

(2.) Sometimes it is caused by sudden chokage of the jet.

(3.) In the case of a single-cylinder engine it is sometimes due to a broken valve.

It should be noted that the symptoms in this case differ from those just described, in that there is no misfiring or any warning. It is very rarely the carburetter, and nearly always the ignition, that is at fault. If a magneto is fitted, the contact breaker should be examined, as the cause is most likely here or in the high tension brush.

Loss of Power.

The most common causes are

(1.) Loss of compression.
(2.) Excess of carbon deposit in the cylinder.
(3.) Insufficient petrol reaching the carburetter.
(4.) Frozen carburetter.
(5.) Batteries partially exhausted.
(6.) Partially choked jet.
(7.) Bad lubricating oil.
(8.) Insufficient lubrication.
(9.) Water boiling.
(10.) Insufficient lift, generally of exhaust valve.
(11.) Incorrect valve timing.
(12.) Valve springs too weak.
(13.) Wrong mixture.
(14.) Wheels out of alignment.
(15.) Axles out of parallel.
(16.) Silencer choked.
(17.) Brakes binding.

If the car is an old one it may require general overhauling, the trouble being due to a collection of faults throughout the car. If it is a new one the back wheels should be jacked up to see that they are quite free, as very often a great deal of power is lost due to binding brakes or wheels running out of track. The most general causes are loss of compression and the presence of carbon deposit. In any case it is advisable to see first that the lubricating system is working all right, and that the oil is not leaking at the crank chamber, either due to leakage at the bearings or joints, or to one of the oil plugs having dropped out.

Engine Runs with Switch Off.

The usual causes are

(1.) Presence of carbon deposit in the engine.
(2.) Defective switch.
(3.) Overheated engine. Short circuit in the primary system when accumulator ignition is used.

Of these, the most general cause is spontaneous ignition, which occurs when the engine gets hot, either due to the sparking plug points becoming incandescent or to an excess of carbon deposit. This occurs most easily with high compression engines. The carbon deposit should be removed and the cooling system overhauled.

Engine Preignites and Knocks.

(1.) Carbon deposit or incandescent sparking plug.
(2.) Short circuit in primary system.
(3.) Engine too hot.
(4.) Compression too high in relation to gear and engine speed.

Here again carbon deposit and too high a compression are the usual culprits. Sometimes the trouble can be remedied by changing the sparking plug. On a high speed engine the rapid passage of current through the sparking plug causes the points to become very hot, which can be overcome to a great extent by using double pole ignition or a sparking plug with very thick points. Knocking may be due to the ignition being too far advanced or to the gear being too high. For high compression engines the gear should be low, otherwise preignition and knocking are bound to occur. Another cause of knocking is looseness of the attachment of the flywheel to the crankshaft, and, of course, worn engine bearings.

Engine Gets Too Hot.

(1.) Defective water pump.
(2.) Radiator choked with fur or mud.
(3.) Choked silencer outlet.
(4.) Water leakage.
(5.) Insufficient lubrication.
(6.) Insufficient lift of exhaust valve.
(7.) Mixture used being too rich.

The general causes and remedies are set out on page 74, and need no further remarks here. It is obvious that if the engine once cooled properly, it can be made to do so again, and the fault is not a very difficult one to remedy.

Bad Compression.

This is usually due to

(1.) Burnt exhaust valve.
(2.) Exhaust valve not ground in properly.
(3.) Copper and asbestos washer leaking.
(4.) Piston rings sticking, or turned round so that their slots are in line.
(5.) Leaking sparking plug.
(6.) Valve stem touching valve tappet.
(7.) Grit on valve face.
(8.) Porous cylinder casting.
(9.) Cylinders worn taper.

The most general causes are the exhaust valves, which require grinding in as described, or the piston rings, which may have turned round so that their slots come into line. After 30,000 miles the cylinder and piston may have worn so much as to permit leakage past the pistons, the only remedy being to rebore the cylinder and fit correspondingly larger piston rings.

CHAPTER X.

THE IMPORTANCE OF CORRECT TIMING.

AS the power obtained from a petrol engine results from a very large number of explosions per minute, it is obvious that the exact time at which ignition should take place is very important, and it may well be assumed that there is a correct position of the piston's travel at which the valves should be opened and closed and ignition should take place. The valves have, therefore, to be timed very accurately if the best power is to be obtained from the engine. The very great importance of absolutely correct timing is not generally understood, and on that account a chapter is devoted to this subject, as frequently an engine is taken down, carefully cleaned and otherwise attended to and reassembled, only to give worse results than it gave previously, which is generally on account of some error in resetting the valve, gear, or ignition.

Fig. 52 is a diagram representing the path of the crank pin during the first revolution of its cycle, and fig. 53 is a corresponding diagram showing the path of the crank during the firing and exhaust strokes. In both cases the top dead centre is marked A and the bottom one B.

Every reader is probably aware that the cycle of operations performed in the engine consists of four piston strokes, with from A to B (fig. 52) being devoted to the sucking in or filling of the cylinder with gas, from B to A compression of that gas, whilst from A to B (fig. 53) power is obtained from the compressed gas, which is exploded and allowed to expand, and during the return of the piston from B to A the gas is exhausted. It might therefore be assumed that the inlet valve should open immediately the crank pin reaches the position A (fig. 52), and that it is shut exactly at B, that the exhaust valve should open at B (fig. 53) and close at A, but this is not the case, and the following is the explanation thereof:

It is obvious that no suction can take place until the piston starts to descend, and as for the first part of the movement of the crank pin, say from A to C, fig. 52, the piston has practically not descended at all, and after the crank pin has passed C it commences to descend rapidly; it is of very little advantage to open the inlet valve until the point C is reached. The angle A O C varies with different engines, but may roughly be taken as 10°.

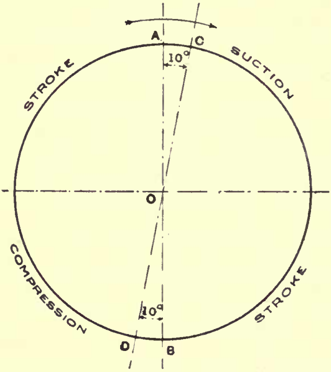

FIG. 52.—Diagram of crank path on suction and compression strokes, A and B being the dead centres.

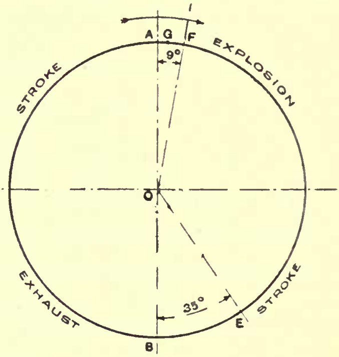

FIG. 53.—Diagram of crank path on firing and exhaust strokes.

During the suction stroke the gas drawn in by the piston moves very rapidly along the pipe, and as the piston moves but slowly as the crank pin reaches the point B, the inlet valve is not closed at the point B, that is to say, the dead centre, but is allowed to remain open, so that the rapidly moving gases may rush into the cylinder as a consequence of their momentum, and aid in filling the cylinder during the time the piston is practically motionless at the end of its stroke. The inlet valve therefore shuts at D. The point D is not a fixed one, varying in different engines, the angle D O B varying between 5° and 20°. For very high speed engines the angle D O B is greater than in low speed engines. This angle is marked in fig. 52 at 10°, though it will be understood that the overlap D O B varies, and if occasion arises to set the inlet valve cam, it should be so arranged that it commences to open the inlet valve about 10° past the top dead centre at C, and should close after the bottom dead centre, the amount of overlap being, of course, determined by the shape of the cam. When the point C is fixed, the closing point D follows as a natural consequence, but if the angle D O B is more than 20° it will probably be found that the engine will not run well at low speed.

Dealing with the exhaust valve, this does not open at the point B (fig. 52), but commences to lift considerably earlier, starting at the point E. Here again practice differs in determining the point of opening, varying between 30° and 45°. The higher the engine speed the earlier the valve opens. It might be taken that the angle B O E (fig. 53) should be about 35°, but for the same reason that the inlet valve is held open until the point E (fig. 52), the exhaust valve does not close until the point F is reached, which practically coincides with the point C (fig. 52). The exhaust valve should therefore close about 10° after the top dead centre, and immediately it touches its seat the inlet valve should open. In a few cases the valves are practically open together, the exhaust valve not having closed before the inlet opens. Having determined the position of the inlet cam, the exhaust valve cam should be set to close the valve at the point F, which practically coincides with the point C (fig. 52). The point of opening E follows as a natural consequence, and depends on the shape of the cam. It should be, as stated, about 35°, and in advance of the bottom dead centre.

Respecting ignition timing, the accumulator system affords a considerable amount of variation by means of the advance spark lever, far more so than is the case with a magneto. In timing the contact breaker in an accumulator system, it should be so set that when fully retarded the spark takes place at the point G (fig. 53), that is to say, slightly after the piston commences to descend. If set in this manner it is impossible for any backfire to occur, and it will be found that the full range of advance can only be used when the engine is running at maximum speed. With the ignition set at the point G the engine should be tried, and if this is too far advanced the contact breaker should be reset to fire slightly later. It must be remembered that a four-cylinder engine fires in the order 1, 3, 4, 2, or 1, 2, 4, 3, starting from either end, generally the radiator end, and it should be seen that the connections to the sparking plugs, coils, etc., are correctly carried out as shown in the diagram on page 45.

In timing a magneto it must first be ascertained which cylinder is on the firing stroke. It will be found that the cranks are probably horizontal, and that the cylinder which is on the firing stroke has its piston about halfway down. The flywheel must therefore be moved backwards to bring that piston right on the top. A dead centre is generally marked on the flywheel, but if not, the flywheel must be moved backwards and forwards to ascertain when the piston is *absolutely* at the top of its stroke.

The magneto contact breaker must now be fully retarded and the armature rotated until the platinum contact points have just broken, the magneto having first been rotated to bring the distributer arm on to the segment which corresponds to the cylinder on the firing stroke. The magneto must then be coupled up to the engine, keeping it and the engine in this position meanwhile, and it will be found that the magneto is timed to fire the cylinders in the right order and at about the right time. Possibly the timing might be slightly early, which can be noted by the inability of the engine to run very slowly and a knocking when the throttle is opened. In such a case the armature should be rotated back very slightly so as to retard the time of firing. It will be understood that the method described provides a starting point, and that the absolutely best position can only be ascertained by trial on the road, the best test being to take a car on to a hill or to accelerate on the flat, and should no knocking take place when the ignition is fully advanced and the car is running slowly, the ignition is too far retarded. If, on the other hand, the magneto cannot be fully advanced at any time without knocking, the magneto is too far advanced.

An alternative method of setting, and a better one, is to set the engine on a dead centre, putting the distributer arm into communication with the right cylinder as before, and then take off the top plate of the magneto, exposing the armature, which revolves in the direction of the arrow (fig. 54). The gap at Z between the armature and the corner of the pole piece should be of some known length, which varies with different magnetos, but can be ascertained from the makers. As stated with reference to the other method of locating the magneto, it is always best to test the timing by climbing a test hill or by acceleration on the level.

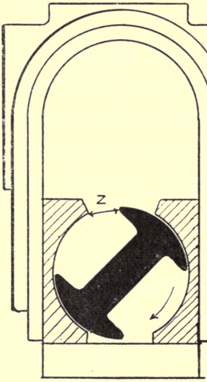

Fig. 54.—Timing the magneto by measuring the gap Z.

CHAPTER XI.

MAINTAINING EFFICIENCY.

NATURALLY if a car is run continuously without receiving the periodic attention which it demands it will gradually fall off in power, and a few hours spent on a general tuning up will be called for. The actual details of this process of tuning up, of course, vary with different cars, but in general it consists in going through the functions of the engine and seeing that each operation is carried out in the best possible manner.

As the reader is aware, the engine operates on the four-stroke cycle, consisting in a suction, then compression, next a firing, and finally an exhaust stroke, and it is necessary to ascertain that each operation, such as suction, compression, etc., is carried out to the best possible effect. Dealing first with the suction stroke, for an engine to give maximum power the cylinder must be completely filled with a mixture of the best firing quality. In course of time the carburetter may become slightly defective, resulting in the mixture being either too weak or too rich, or again in preventing a complete filling of the cylinders. Dealing with the first, the carburetter requires completely cleaning out, particularly the jet nozzle, the bottom of the float chamber, and the petrol filter. If the petrol pipes and the whole of the carburetter can be taken down and all the passages cleaned, so much the better, but usually it is merely necessary to unscrew the jet, clean it, remove the lid of the float chamber, and remove the dirt and water at the bottom. This can be easily effected with a piece of cotton wool, which will soak up the water and the grit. When the float is removed it is well to shake it near the ear to ascertain if it contains any petrol, which should be removed and the leak soldered up as described on pages 61 and 62.

In replacing the parts it is well to see that no leakage takes place where the jet screws into the carburetter, and if it is impossible to make a good joint, either a new washer should be obtained or a small amount of common yellow soap rubbed on the thread, taking care that none of the soap finds its way inside the jet. The use of soap in this manner can be applied to any other petrol joints which leak slightly.

The gauzes in the air intakes and at any other points in the carburetter should be cleaned out, and in the case of a White and Poppe carburetter, if the top of the smaller jet is scored or scratched badly, the carburetter should be sent to the makers so that the jet can be refaced. This scoring very rarely occurs, but it does sometimes happen, and the refacing of the jets by the makers produces wonderfully improved results with regard to slow running and fuel consumption.

It is necessary to see that all the joints in the induction pipe are tight, and it is advisable that a little boiled oil be smeared on this so as to prevent any gas leaks. This boiled oil is merely linseed oil boiled until it reaches the consistency of treacle. It is applied cold to the surfaces after they have been cleaned, and the joint tightened up.

If automatic air valves are fitted they should be removed and cleaned, so as to prevent any chance of sticking, care being taken to replace the valve at the same adjustment as before. This adjustment will probably require a slight alteration when the tuning up process is completed.

Regarding the compression stroke, it will be found that here lies the chief weakness. It will be necessary to grind in the exhaust valves, and possibly also the inlets. Perhaps it will be necessary to remove the cylinders, to reset the piston rings, and even to fit new ones if the car has been running a considerable time.

The necessity for fitting new rings arises earlier or later with different makes of cars. They should not be called for before 10,000 miles are done, and many engines of good make do not require replacements of this kind till 30,000 miles have been covered. If the engine is a very old one it might be necessary, in order to restore the compression, to rebore the cylinders, which may have worn slightly oval. Naturally once the cylinders are removed all carbon deposit should be cleaned off the piston head and cylinder surfaces, which is very necessary after a car has been running a long time.

Having restored the compression, it is necessary to turn to the firing stroke, and the ignition apparatus, whether a coil or magneto, should be overhauled. With accumulator system the wires should be examined for breakages or chafed insulation, and probably new ones fitted. The platinum points should be trimmed, and possibly renewed, and the trembler adjusted, and the contact breaker, if of the wipe type, cleaned out and new brushes or blades fitted.

If a magneto is used the contact breaker must be detached and the points trimmed, and before the contact breaker is replaced it must be adjusted so that when the rocker is lifted there is the correct gap between the platinum points. This gap should be about $\frac{1}{2}$ mm., but a gauge giving the correct dimensions can be obtained from the manufacturers. The carbon brushes should be removed and cleaned, and possibly, though extremely unlikely, the magnets may require remagnetisation. As stated in Chapter III. dealing with magneto ignition, remagnetisation is very rarely called for. The sparking plugs should be removed, cleaned, and readjusted, or new ones fitted. Any slackness between the contact breaker and the advance spark lever should be taken up, and the same applies to the other engine control rods.

Little goes wrong with the exhaust system. To run the engine as quietly as possible, new washers are required at the ends of the various pipes, particularly between the main pipe and the cylinders. The silencer may require removal and taking to pieces in order to clear it from the soot which accumulates in it. This is very necessary, especially if a hissing noise accompanies the exhaust. The valve tappets require careful adjustment after the cylinders have been removed and the valves ground in.

Sometimes a car will run sluggishly, and thorough tuning up as described will not restore it to its proper condition. The cause in this case often lies behind the engine, and may be due to the use of too little lubricant in the gear box, axle, or universal points, or too thick a grease in the gear box or axle casing. To obtain good power from a car it is obvious that the transmission system must be perfectly free, and it must be ascertained that the brakes are not rubbing nor the wheels out of track so as to cause the tyres to drag and set up a retarding effect. The water circulation system requires little attention. If the pump gland leaks it may require restuffing, as described on page 77. If the engine is found to boil considerably it is possible the cooling system may have silted up owing to the presence of lime in the water, which causes a furry deposit on the walls of the radiator and water jacket. This can be removed as described on page 73.

Obviously if a car has been running a very long time the main engine bearings may have become worn and require taking up. In such a case the job should be put in the hands of the manufacturers or a really good repairer, as the treatment necessary is beyond the scope of the average motorist.

CHAPTER XII.

USEFUL INFORMATION.

How to Solder.

IT is highly useful for anybody concerned with the maintenance of a motor car to know how to effect small soldered repairs, particularly soldered pipe joints.

The process of soldering consists in causing a molten mass of metal to run between the two parts to be joined together and to adhere to the two parts. Solder will not adhere to a dirty surface, and one of the most important points is, therefore, to see that the surfaces are perfectly clean. The following is the usual procedure for soldering a brass nipple on to a copper pipe, such as a petrol pipe, what is known as soft solder being used, though it is better to use hard solder, or even brazing ; but these are generally beyond the capability of the amateur.

If the petrol pipe attachment be examined, it will be found to include a brass union nut, which screws on to the carburetter or petrol tank, and a conically ended nipple, which is soldered on to the pipe. If the pipe is broken off. the first thing to do is to remove the old nipple, which can be done by holding it in a gas Bunsen flame or that of a blow-lamp until it is almost red-hot. This will melt the solder lying between the copper tube and the brass nipple, freeing the two, and allowing the pipe to be pushed out of the nipple by means of the tang of a file, a gimlet, or some other suitable tool. If the parts have been brazed together, it will be impossible to separate them, and a new nipple must be obtained. If they are hard-soldered, which can be ascertained by the fact that it is impossible to separate them in the ordinary flame, an attempt should be made by getting them as hot as possible. If this is unsuccessful, a new nipple must be used. One or two nipples and unions of standard size should be kept in the garage, as they only cost a few pence, and are very useful.

Assuming the nipple to be ready for attachment, the first thing to do is to try and slip it on the petrol pipe. It will probably be found that the pipe is too large for the hole in the nipple, which is as it should be, as it allows for filing up and cleaning of the parts. If the pipe is only a very small amount too large for the hole in the nipple, it can be reduced sufficiently by means of a piece of emery-cloth. The pipe should be gripped gently in a vice, leaving about an inch projecting. A strip of emery-cloth about threequarters of an inch wide should be torn, and with this the end of the pipe should be cleaned by pulling the strip backwards and forwards around the pipe end. This must be done equally all round, so that the end of the pipe remains circular, and care should be taken that the pipe is not tapered off too much. The inside of the nipple should be cleaned. It does not require very much cleaning, because as a rule it is almost ready for soldering. The tang of a file or the end of a small knife blade, etc., can be used to scrape round the inside of the nipple. The two parts should then be of sufficient size to slip easily into place. If too tight it will be impossible for the solder to run in between. Equally, of course, there should not be too much clearance. It is advisable at this stage to blow down the pipe and clear out any of the emery dust, filings, or other grit. Also it is essential that the inside of the pipe should be cleaned of oil or grease, as this causes smoke during the soldering process. The union nut must next be slipped on to the pipe, and care should be taken to see that it is the right way round.

The flame should now be lit, or the blow-lamp set going, and the end of the pipe and the nipple should both be held in the flame by means of pliers. When the pipe is hot enough it should be dipped into some killed spirits, and the cleaned surface coated with this flux (of which more later). The inside of the nipple should be similarly treated with the flux and a few bits of solder placed on the hot, flux-covered end of the petrol pipe, and allowed to run and spread out over the surface. The nipple can then be slipped on to the pipe, the two parts, of course, being maintained hot all the time. In sliding the nipple on to the pipe, it should be twisted backwards and forwards, so as to spread in each direction, and if desired some solder can be added round the pipe near the end of the nipple holding the nipple downwards, so as to allow the extra solder to run between the surfaces. When finished, the parts can be immersed in water, and then cleaned up. *An important point often overlooked is that the union nut should be put in place before the union nipple is soldered on to the pipe.*

The killed spirit is used merely as a flux to cause the solder to flow over the surface. It consists of hydrochloric acid with some zinc dissolved in it. A two ounce bottle of concentrated hydrochloric acid should be obtained and a few chips or shavings of zinc dissolved in it until the solution is saturated—that is to say, until a point is arrived at when no more zinc will dissolve. The surplus zinc should be removed, and it is advisable to add about a teaspoonful more of the acid. The flux is then ready for use.

If desired, resin can be used as a flux, and is preferable for soldering two copper parts together. It must be understood that in soldering the solder has to undergo two changes. First, it has to melt, which is indicated by its forming into a ball. It then has to "run," which it will not do unless the surfaces are perfectly clean, flux-coated, and hot enough. Directly the solder has run, it will be found to have covered the coated surfaces, and when all the surface is covered with solder the job is finished.

A soldering paste called Tinol is now on the market, which is a soldering mixture including a flux. This is all ready for use, and is perhaps the easiest thing for an amateur to use. In using Tinol the nipple should be put on the pipe after the surface has been cleaned thoroughly, and then be held in the flame till it is hot, taking care that the nipple remains in its proper place all the time. The parts can then be drawn from the flame, and with a match or piece of wire a small quantity of solder can be placed on the pipe close to or touching the nipple. If the parts are hot enough the Tinol will melt and run down between the nipple and the pipe. This should be repeated all the way round the nipple, and it will be found that a very secure attachment can be quickly and easily obtained.

With regard to the flame necessary, a Bunsen gas burner is probably the best; and if desired a blow-pipe can be used with it. This is probably preferable where the solder and flux are used separately. The blow-pipe is held close to the bottom of the flame, about an inch from the top of the burner. The thick end of the blow-pipe is held in the mouth, and by means of the small end a jet of the hottest part of the flame may be thrown on to the solder, getting this very hot, and causing it to melt and run. Where the parts being dealt with are small, as in the case of a pipe and nipple, they can be held directly in the flame. But where the parts are large, soldering cannot take place until the surfaces are hot enough, which in most cases means heating the whole of the article, but this can be obviated by the use of a blow-pipe.

As an alternative a soldering-iron can be used. This consists of a tool having a wooden handle and a copper bit at the end. The tapered end of the bit must be cleaned by means of a file, and then the iron put in the flame and heated up until it is almost but not quite red-hot. Whilst the iron is heating, some of the spirit, which forms the flux, should be poured out into a lid of a tin, and in a corresponding tin lid can be put a few chips of solder. When it is hot enough the end of the iron is dipped into the spirits, and from that into the other tin lid, so as to touch the solder chips, and it will be found that the chips will adhere to the bit, coating it. The bit should be turned round, so that all sides of the copper end for threequarters of an inch up are coated with solder. The iron is now "tinned," and can be put back in the flame for its final heating. To use the iron a piece of solder is put in place and pressed with the tip of the bit. The heat in the copper bit is imparted to the solder, causing it to melt and run. From time to time the iron requires "tinning," the necessity for which can be ascertained by an inspection of the bit. It should all the time be well coated with solder.

The copper bit should be soft, and constant use hardens it, unless when it is cooling down it is occasionally immersed in cold water.

Where a gas burner is not accessible a blow-lamp can be used, and for amateur motorists a small petrol lamp, such as is sold by Markt and Co., or any other accessory manufacturer, is quite sufficient. The large blow-lamps burning paraffin are rather a nuisance, and difficult to use unless they are handled frequently.

How to keep Some Things Tight and Loosen Others.

The amateur motorist will soon find that it is very necessary to keep nuts, etc., screwed very tight, particularly on single-cylinder cars, as the vibration is apt to turn a slack nut, possibly causing thereby an accident or a breakdown.

There are various methods of securing a nut on a bolt. One is to screw down on top of the first nut a second nut, termed a lock-nut. Another is to place under the nut a spring or Grover washer, which can be obtained from any accessory dealer. As an alternative a split pin can be used, which will entail drilling of the bolt In some cases moistening of the bolt stem and the interior of the nut, and allowing these to remain moist during the night, will create a small amount of rust which will cause the nut to rust on the bolt. Similarly a coat of paint applied to the nut and bolt is very effective.

Conversely it is often found difficult to unscrew certain parts. For instance, the radiator cap may be found to be immovable. A very simple way to remove this is to wrap the cap in the corner of a chamois leather or rag, and then twist up the rag tightly until it forms a kind of lever or spoke projecting from the cap, which will afford a very tight and good grip owing to the pressure exerted by the twisted-up part. By these means a splendid grip can be obtained of the radiator cap, and it will be found that it can be easily unscrewed.

If an accumulator terminal is found to be set fast a pair of pliers should be heated till they are as hot as can be held in the hand, and then be caused to grip the terminal nut for a few seconds so as to heat the nut, after which the pliers can be turned to unscrew. Subsequent sticking of the terminal can be prevented by applying a little vaseline or oil to the threads.

A valve cap sometimes sticks in very tight, and resists removal without great risk of damage. A simple method of freeing this is to run the engine so as to warm up the parts, and then, when the engine has been stopped, to pour some water on the valve cap in order to cause it to contract. If the valve cap is recessed, some cold water can be poured into the cap. Since the cap contracts as it cools down, it will be found to free itself so much that it can be unscrewed quite easily.

The Motor House.

It is advisable to provide a special building for the motor house, and not to use an old coach-house if it can be avoided, as the requirements in the two cases are very different. Good advice as to the construction of motor houses will be found in *The Autocar* of August 19th, 1911 ; but, briefly, it may be stated here that the floor should be level, and not sloped for drainage. It should be of blue bricks or stone flags, cement being very unsuitable, as it corrodes under the action of oil. If a pit be used, it should be arranged transversely to the car, provided there is sufficient room in the house to admit of the car being wheeled backwards and forwards, so that access can be had to all mechanism. Petrol fumes descend, so that naked lights should not be used on the floor nor in the pit. A pit is very liable to act as a trap to collect any petrol fumes that may be set up. Great care should, therefore, be taken not to drop any petrol into the pit.

The entrance doors should be wide, also the passage or drive up to the motor house; and outside the doors of the shed should be arranged a washyard, also blue-bricked, which it is advisable to roof over. All roofs should be guttered, and the rain-water should be collected in a butt if possible, as it is better to use rain-water in the radiator than the ordinary town supply. In determining the size of the motor house it is advisable to make it sufficiently large to accommodate the biggest type of car, as, although the motorist may start off modestly with a small vehicle, there is not the least doubt but that he will become more ambitious, and, furthermore, it is quite possible he may have to put up a friend's car now and again. The minimum dimensions should be 20ft. from front to back, 10ft. in width, and the same in height. If more room can be allowed, so much the better, as it leaves plenty of space for a carpenter's bench, spares, etc. All woodwork in the motor house should be painted over with uninflammable paint, and some form of fire extinguisher is advisable.

To Prevent Chokage of Acetylene Burners.

The light should never be permitted to burn itself out, as an accumulation of carbon is left on the burner. To keep the burner clean it should be washed in *liquor potassæ*, and then washed in petrol. The small gas holes should be cleaned with wire prickers, which are generally supplied with the lamps, or should be blown through by means of a bicycle pump inflator.

Wind-screen Treatment.

To prevent wind-screens being rendered opaque in rain there are various preparations on the market, and various home remedies have been suggested—for example, to rub the screen over with a rag moistened with glycerine or a special preparation which consists of a mixture of fifty-five drams of glycerine and one litre of alcohol; or the screen can be rubbed over with a rag which is sticky with soft-soap.

The transparent lights or mica windows in Cape cart hoods are sometimes difficult to clean. This can easily be done by damping the mica with vinegar, and then washing it off with clean cold water.

To Soften Copper Piping, etc.

Commercial copper pipe is stiff and difficult to bend without kinking. For motor car work it should be softened, and in buying it is advisable to ask if it can be supplied soft. If not, it, or any other copper article, can easily be softened by heating to a red heat, and then dipping in cold water so as to cool rapidly. If allowed to cool slowly, a copper article hardens.

To Remove a Broken Stud.

If there is a part projecting, this part should be filed flat and gripped with pliers or spanner. As an alternative a saw-cut can be made in it, and it can be unscrewed with a screwdriver. If there is not sufficient projection, a hole should be drilled vertically in the screw, and the sharp-cornered tang of a file inserted to enable it to be unscrewed. If the amount projecting is large, of course, a nut and lock-nut can be screwed on to the projecting screwed part and the stud unscrewed by applying a spanner to the lower nut. This is the best method of unscrewing a stud, either broken or otherwise; and in screwing a stud into place, the same practice is followed, but the top nut is screwed down.

To Keep a Car Smart.

Each part of the car should be kept clean and smart-looking. In this connection the silencer is often overlooked, and allowed to remain rusty and dirty, whilst the same applies to the exhaust pipe. To keep the exhaust pipe clean a few drops of oil can be applied to it when warm, and it will be found that the pipe will receive quite a polish after this has been carried out a few times.

If it is actually desired to paint the pipe and silencer, the following mixtures, which make about 2¼ lbs. of paint, can be used:

Boiled linseed oil	⅕ lb.
Japan varnish	⅕ lb.
Spirits of turpentine	⅖ pint
Lampblack	1½ ounces
Pure powdered graphite	1½ ounces
Powdered oxide of manganese	¾ ounce

To make, mix the linseed oil with the Japan varnish, then add the lampblack, graphite, and the manganese in the order stated, stirring all the time. As the mixture thickens, it should be thinned down with turpentine until the quantity mentioned is added. The paint dries very quickly, and requires constant stirring. It should be applied to the silencer when the latter is hot and clean outside.

To keep rubber mats white, they should, from time to time, be painted over with a mixture of whiting and milk.

In conclusion, the amateur motorist will find a bulk of useful information in a companion handbook entitled "Hints and Tips," issued by the publishers of this volume.

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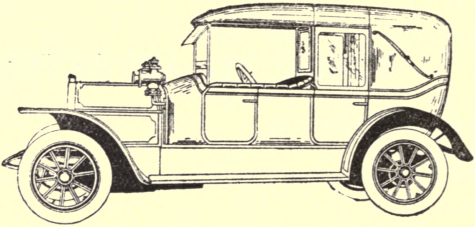

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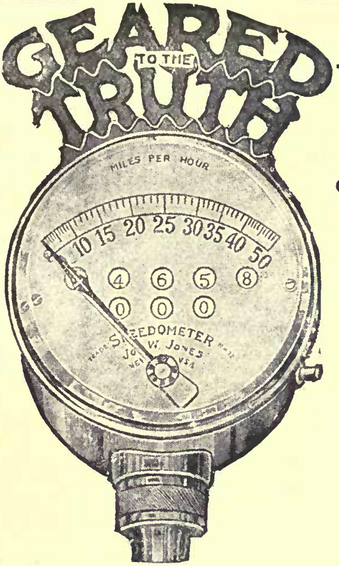

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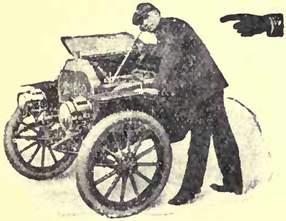

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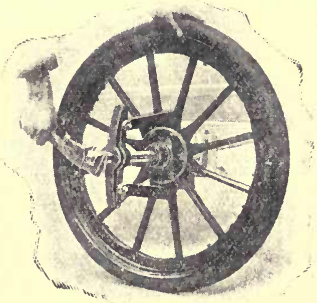

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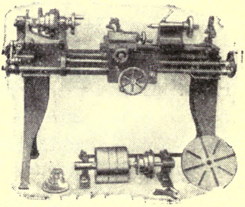

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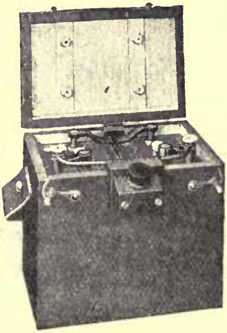

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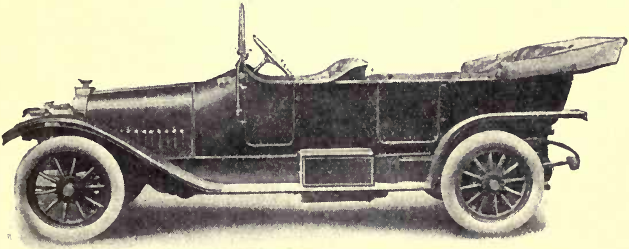

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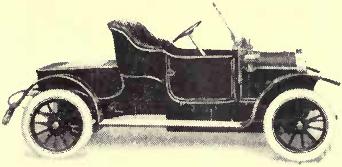

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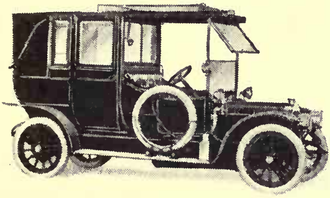

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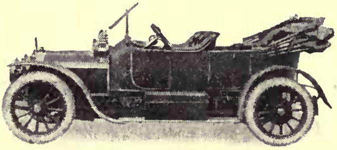

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